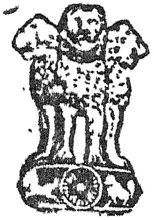

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PAPERS.

1. On the External Characters of existing Chevrotains.

By R. I. Pocock, F.R.S., F.Z.S.

[Received February 4, 1919: Read February 18, 1919.]

(Text-figures 1–5.)

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Generic names.—Gray (Cat. Rum. Mamm. Brit. Mus. pp. 97–99, 1872) referred the Chevrotains to two families: the Tragulidæ for the Oriental species, and the Hyemoschidæ for the single West African form. Furthermore he admitted two genera of Tragulidæ, namely *Meminna* or, as it should have been, *Memina* according to his original spelling of the name in 1821 (Med. Repos. xv. p. 307) for the spotted Indian and Ceylonese species *meminna*, and *Tragulus* for the unspotted species occurring to the east of the Bay of Bengal.

The family Hyemoschidæ does not appear to have been adopted by later writers, and the genus constituting it has been usually cited as *Dorcatherium*. Also no one seems to have followed Gray in granting generic status to *meminna* (cf. Lydekker, Cat. Ung. Mamm. iv. pp. 261–298, 1915). But in 1916 Thomas (Ann. Mag. Nat. Hist. (8) xviii. pp. 72–73) gave subgeneric rank to *meminna*, adopting for the species the name *Moschiola* Hodgson, as quoted by Gray, on the grounds of the preoccupation of *Memina* or *Meminna* by G. Fischer in 1814. Furthermore he showed, in opposition to Merriam's opinion, that *Tragulus* is typified by one of the larger spotless Oriental species, and that *Hyemoschus* should stand for the West African form, which may be generically distinguished from the now extinct European *Dorcatherium*.

In the following pages I adopt Thomas's nomenclature but, for what appear to me to be good and sufficient reasons, I give full generic rank to *Moschiola*.

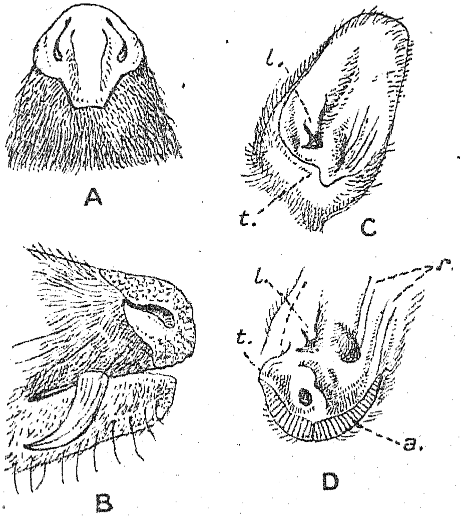
The materials on which this paper is based were fresh examples of the following species: *Hyemoschus aquaticus*, *Moschiola meminna*, *Tragulus javanicus*, *T. kanchil*, and *T. stanleyanus*.

Coloration.—As is well known, *Hyemoschus* and *Moschiola* differ from *Tragulus* in retaining on the body a distinct pattern of white spots which on the flanks fuse, or tend to fuse, into longitudinal stripes and on the croup frequently exhibit a transverse arrangement. The pattern recalls that of the Tragelaphine Pecora; and in this connection it may be noted that *Hyemoschus* is white on the front of the pasterns as in typically marked examples of those antelopes.

There are also some interesting points connected with the peculiar pattern of the neck and throat in these primitive Ruminants. In *Moschiola* there is a continuous white median stripe of considerable width running from the chin on to the abdomen. From a point a little behind the corner of the mouth this white *median* stripe gives off on each side a single white lateral stripe which runs along the side or lower edge of the mandible and ceases approximately on a level with the point of attachment of the posterior edge of the ear. From its position this may be called the *mandibular* stripe. Towards the middle of the throat the median white stripe branches again, giving off on each side a second, or *jugular* stripe which passes obliquely backwards for a short distance in the direction of the shoulders, but is much shorter than the mandibular stripe. Thus in *Moschiola* the mandibular stripe is comparatively long and the jugular stripe short, and both arise from an uninterrupted median white band traversing the throat from end to end and passing on to the chest, with only a slight extension of pigmented hairs inwards towards the middle line where the throat passes into the chest.

In *Hyemoschus* the same general arrangement prevails, but both the *mandibular* and *jugular* stripes are much longer, the former passing beyond the level of the ear well back on to the side of the neck, and the latter reaching almost to the shoulder. Moreover, there is no encroachment of pigmented hairs where the white of the throat runs into that of the chest. *Tragulus* differs both from *Hyemoschus* and from *Moschiola* in having the mandibular stripe undeveloped or very short. The jugular stripe, however, is as long as in *Hyemoschus*, but the dark band which separates it from the median white band on each side is broader posteriorly and is continued farther forwards and frequently meets its fellow of the opposite side a little behind the line of the angles of the jaw, thus dividing the white of the interramal area from that of the throat. Moreover, the white area of the throat, which is much broader behind than in front, is separated from the white of the chest by a dark transverse band.

Text-figure 1.



A. Rhinarium of *Hyemoschus aquaticus*, from above.
B. „ *Moschiola meminna*, from the side.
C. External ear of *Hyemoschus aquaticus*. *t*, tragus; *l*, lappets overlying the depression.
D. The same, with the external rim of the capsule cut open behind the tragus, showing the auditory orifice. *t*, tragus turned forwards; *l*, lappets; *r*, supporting ridges; *a*, cut edge.

The *Rhinarium* in the three genera is large, naked, and sculptured by grooves into larger and smaller areas. Its dorsal surface extends backwards some distance behind the posterior angle of the nostrils, which are comparatively narrow and slit-like, but not more valvular than in the Cervidæ. The area of the rhinarium beneath them is deep laterally and wide in front, wider than the internarial septum and as wide as the anterior rim of the lower lip (text-fig. 1, A, B).

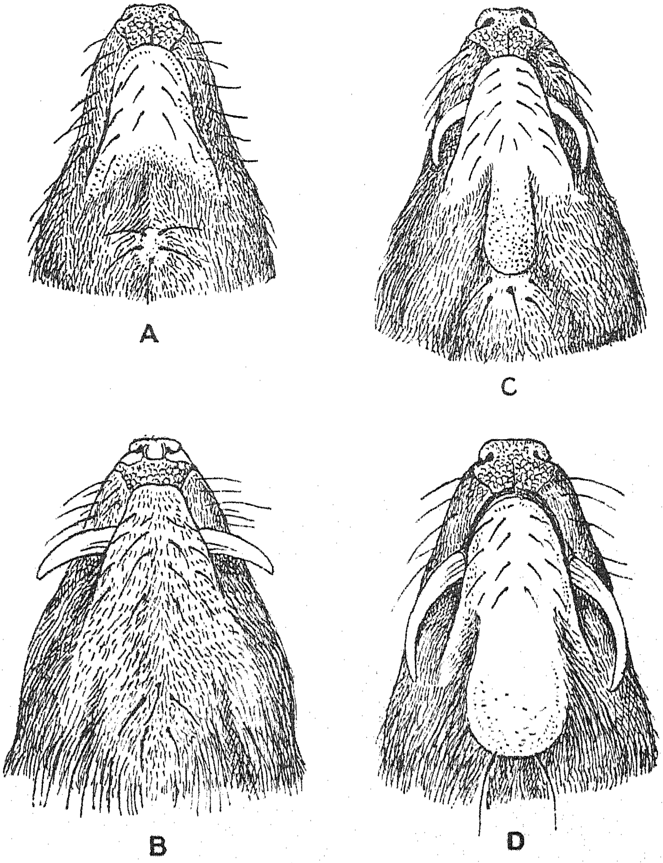
The *Facial vibrissæ* are generally well developed, consisting of mystacial, submental, superciliary, subocular, and genal bristles, two pairs of genal tufts being frequently present. The superior tuft is situated either high up about halfway between the eye and the ear but at a lower level, as in an example of *Tragulus stanleyanus*, or below the corner of the eye, as in a specimen of *T. kanchil*. The inferior tuft, represented by a single bristle, arises some distance behind the corner of the mouth. Both tufts, however, are not always present. When they are present, the full complement of vibrissæ coincides with that of some small Cervidæ and Bovidæ and, as I have elsewhere remarked, with that of typical Carnivora. The submental vibrissæ are arranged in definite lines. The interramal tuft, which is of special interest, is described in the following paragraph.

The Interramal gland.—In *Moschiola* (text-fig. 2, B) the chin and interramal area are covered with hairs which are short on the chin and gradually become longer on the throat, without showing any sharp line of demarcation. The interramal tuft of vibrissæ, consisting of two pairs of bristles, sometimes with an additional median one, is set in the posterior half of the interramal area. In *Hyemoschus* (text-fig. 2, A) the chin is scantily covered with fine short hairs sharply defined from those of the throat, which are longer than in *Moschiola*. The interramal vibrissæ, consisting of two or three pairs of bristles and one unpaired, making five or seven in all, form a cluster as in *Moschiola*. In *Tragulus* (text-fig. 2, C, D) the chin is even more scantily hairy, apart from the submental vibrissæ, than in *Hyemoschus*, but it is not naked as described originally by Gray and recently by Lydekker in his Catalogue, although it appears to be naked when examined by the naked eye. Behind the chin there is a tongue-shaped area of skin, covered, like the chin, with short hairs and extending backwards along the middle of the interramal area as far as the interramal tuft of vibrissæ which is set at its posterior edge. This tract of skin overlies a cutaneous gland which is sometimes so thick posteriorly that in profile view it forms a swelling projecting well below the inferior edges of the mandibular rami. The presence of this gland, which has been noticed by previous authors, serves to distinguish *Tragulus* from *Moschiola* and *Hyemoschus*.

In an adult male of *T. stanleyanus* (text-fig. 2, D) there was only a single pair of interramal vibrissæ arising near the posterior edge of this gland. In one example of *T. kanchil* there were five vibrissæ arranged in a transverse row. In another example of the same species there were three pairs of these vibrissæ, and in one example of *T. javanicus* the arrangement and number of the vibrissæ were the same as in the last-mentioned example of *T. kanchil*. A second example of *T. javanicus* (text-fig. 2, C) showed two pairs of vibrissæ and one bristle in the centre of the area circumscribed by them.

The *external Ear* (text-fig. 1, C, D) is small in all cases, but noticeably larger relatively in *Hyemoschus* than in the Oriental forms. It is attached to the head by a broad base, the narrow elongated cup-shaped base of the typical Ruminantia, in which the ears are highly mobile, being undeveloped. The tragus is

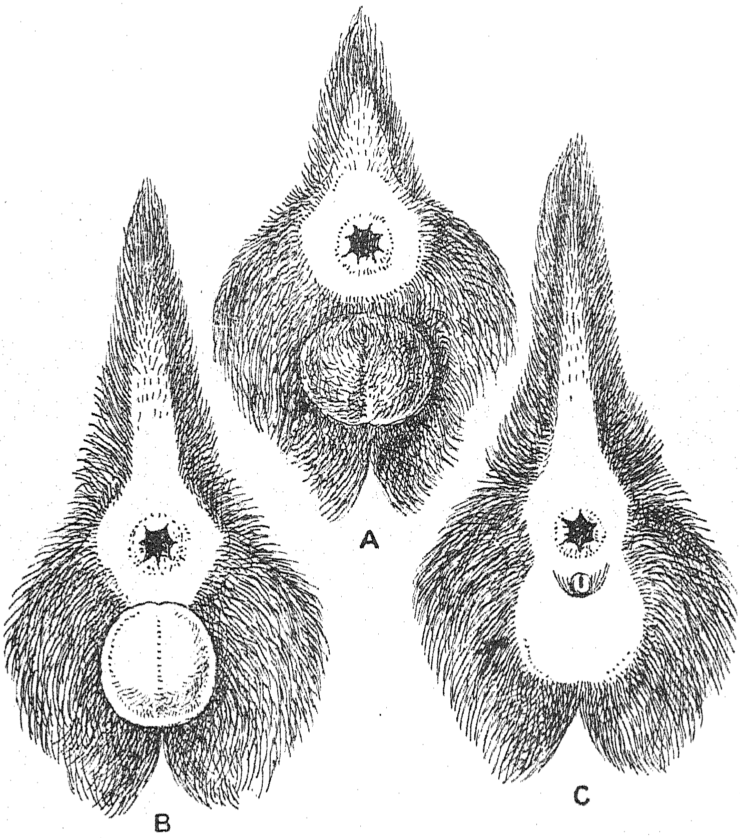
Text-figure 2.



A. Underside of head of *Hyemoschus aquaticus* (♂ immat.), showing tuft of interramal vibrissæ.
B. The same of *Moschiola meminna* (♂ ad.).
C. The same of *Tragulus javanicus* (♂ ad.), showing the interramal gland.
D. The same of *Tragulus stanleyanus*.

merely a small excrescence, but it is better defined in *Moschiola* than in *Hyemoschus* and *Tragulus*. Low down towards the posterior edge of the pinna there is a pair of short strengthening ridges, and in front of these towards the anterior rim of the pinna there is a definite pit or depression overlapped in front and capable of being closed by two lobate thickenings, one above the other, the upper being larger than the lower. The auditory orifice, opening upon a thick ridge-like excrescence, is concealed by the tragal ridge which forms the external border of the capsule of the pinna.

Text-figure 3.



A. Anal area of *Moschiola meminna* ♂, showing the short tail and the hairy scrotum.

B. The same of *Tragulus javanicus* ♂, showing the long tail and the naked scrotum.

C. The same of *T. javanicus* ♀, showing the naked area round and below the vulva.

The ear of the Tragulidæ differs from that of the Pecora in three particulars, namely, in the breadth of its basal attachment to the head, in the development of only two supporting ridges, both placed near the posterior rim, and apparently in the presence of the depression overlapped by lobes in the position of the supratragal ridge of the normal mammalian ear.

The *Tail*, as is well known, varies in length. In *Moschiola* (text-fig. 3, A) it is very short. When depressed, its tip reaches the scrotum * but does not conceal it, and the scrotum is covered with hair. In *Tragulus* (text-fig. 3, B, C) the tail is much longer and covers the scrotum, which is naked except laterally at the base. Similarly in the female the tail covers the genital orifice, which is situated at the upper end of a large tract of naked skin. In *Hyemoschus* the tail is at least as long as in *Tragulus*, but the subcaudal area is not naked as in that genus but somewhat thinly covered with fine white hairs.

The *Legs* of the Tragulidæ, as compared with those of the Pecora, are remarkable for the shortness of the metacarpal area, a primitive character recalling the condition seen in the Suidæ. In *Hyemoschus* the legs and feet are relatively much stouter than in *Tragulus* and *Moschiola*, in which they are slender and delicate, and in the African genus the interdigital integument forming the floor of the interdigital depression reaches a little nearer to the heels of the hoofs than in its Oriental allies. In the three genera there is a smooth pad of moderately thickened, naked skin on the posterior side of the hock (calcaneal area). This pad is indistinctly defined in *Tragulus*, but is sharply defined in the other genera.

In *Hyemoschus* (text-fig. 4, C, D) the metacarpal and metatarsal areas are everywhere thickly covered with hairs. Those on the back of the metacarpus grow downwards, whereas on the back of the metatarsus they grow backwards on each side, forming a median crest. The back of the pasterns between the false hoofs and the true hoofs is naked, except for a few hairs in the middle line, and the walls and floor of the interdigital cleft in front are also almost naked.

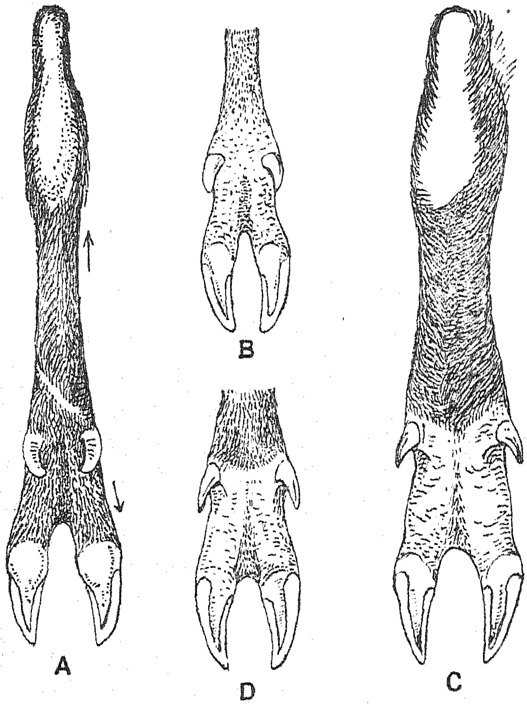
In *Tragulus* (text-fig. 4, B) the metacarpal and metatarsal areas are everywhere comparatively scantily hairy, especially on their posterior sides where the hairs are so short and sparse that their surfaces have been described as naked. The hairs cease altogether some little distance above the false hoofs. Hence the nakedness of the back of the pastern may be said to extend above the false hoofs, a condition not observable in *Hyemoschus*. The interdigital cleft in *Tragulus* is also naked to all intents and purposes, as in *Hyemoschus*.

In *Moschiola* (text-fig. 4, A) the metacarpal and metatarsal areas are as hairy as in *Hyemoschus*, but on the posterior side of the metatarsus the hairs grow upwards from a line a little above the false hoofs where there is a definite parting, the hairs below the line growing downwards. *Moschiola*, however, is distinguished both from *Hyemoschus* and *Tragulus* by having the posterior sides of the pasterns and the interdigital clefts hairy instead of almost naked.

---

* It may be noted that the scrotum in these primitive Ruminants is sessile and set high up on the perineal area just beneath the anus and is not pendulous between the hind limbs as in the Pecora. Its position recalls that of the scrotum in the Suidæ and Camelidæ

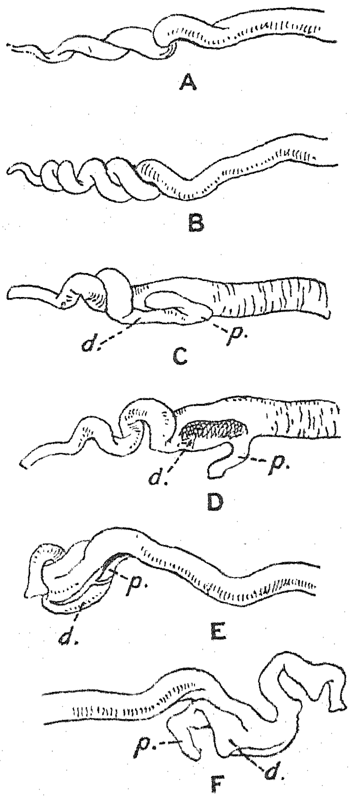
Text-figure 4.



A. Posterior surface of hind leg of *Moschiola meminna*, the arrows showing the direction of the hair-growth.
B. Posterior side of fore foot of *Tragulus javanicus*.
C. Posterior side of hind leg of *Hyemoschus aquaticus*.
D. Posterior side of fore foot of the same.

The *Penis* of an undetermined species of *Tragulus* was figured and described by Lönnberg (Nova Acta. R. Soc. Upsal. (3) xx. p. 33, pl. ii. fig. 20, 1904). The penis of an example of *T. stanleyanus* (text-fig. 5, C, D) agrees tolerably closely with it except that there is an additional coil on the spirally twisted terminal portion, possibly due to its being more contracted. As in Lönnberg's specimen there is at the base of the spirally twisted termination a well-developed lamina ending proximally in a free process, the two combining to give the incrassate appearance to the distal end of the organ. Normally this lamina and its process are closely folded on the shaft of the penis, but they are capable of being unfolded and spread (text-fig. 5, D).

Text-figure 5.



A. Extremity of penis of *Hyemoschus aquaticus*, from the left side.
B. The same of *Moschiola meminna*.
C. The same of *Tragulus stanleyanus*, with apex coiled and lamina folded up.
D. The same, with apex partially uncoiled and lamina unfolded.
E. The same of *Tragulus kanchil* folded up.
F. The same from the right side, with the apex and the lamina partially unfolded.

Lettering:—*d*, distal, and *p*, proximal portion of the lamina in the two species of *Tragulus*.

The penis of *Tragulus kanchil* (text-fig. 5, E, F) resembles in a general way that of *T. stanleyanus*, but there are some well-marked differences. The spirally twisted portion is here and there thickened and geniculate and the lamina is somewhat differently shaped. When the penis is contracted the spirally twisted portion and the lamina are tightly folded together into a thickened knot.

The penis of *Moschiola meminna* was figured and described by Gerhardt (Verh. Deutsch. Zool. Ges. xvi. p. 153, 1906). The penis of an example I examined is in close agreement with it. It ends in a long, many-coiled portion, with an acuminate tip and there is no lamina (text-fig. 5, B).

In *Hyemoschus* (immature example) (text-fig. 5, A) I find the penis to be in general agreement with that of *Moschiola*, the point being sharp and the lamina absent, but the spiral twists of the terminal portion are not so numerous or so close, the twisting resembling rather that of a "gimlet" than of a "corkscrew," to which the twisting seen in *Moschiola* may be compared.

The incidence of the characters above described may be epitomised as follows:—

1.	*a.*	Body spotted and striped with white	*Moschiola, Hyemoschus.*
	b.	Body unspotted	*Tragulus.*
	c.	Mandibular stripe moderately long, jugular stripe short	*Moschiola.*
	d.	Mandibular and jugular stripes both long	*Hyemoschus.*
	e.	Mandibular stripe short or absent, jugular stripe very long	*Tragulus.*
2.	*a.*	Interramal gland absent	*Moschiola, Hyemoschus.*
	b.	Interramal gland present	*Tragulus.*
3.	*a.*	Tail short, scrotum and inguinal region hairy	*Moschiola.*
	b.	Tail long, scrotum and inguinal region hairy	*Hyemoschus.*
	c.	Tail long, scrotum and inguinal region naked	*Tragulus.*
4.	*a.*	Legs and feet stout and strong	*Hyemoschus*
	b.	Legs and feet fine and slender	*Moschiola, Tragulus.*
	c.	Legs and feet normally covered with hair (apart from the hock-pad)	*Moschiola.*
	d.	Legs normally hairy, back of pasterns and interdigital cleft almost naked	*Hyemoschus.*
	e.	Legs very scantily hairy below knees and hocks behind, back of pasterns and interdigital cleft almost naked	*Tragulus.*
5.	*a.*	Penis simple, attenuated, spirally coiled distally, without lamina	*Hyemoschus, Moschiola.*
	b.	Penis complex, spirally coiled distally but provided with a lamina normally folded up behind and beneath the twisted termination	*Tragulus.*

Collecting the characters under generic headings yields the following diagnoses:—

Genus Tragulus Pallas.

Body unspotted; mandibular white stripe short or absent, jugular stripe very long; white of throat narrow, separated from that of chest and almost or entirely separated from that of interramal area.

An interramal gland covered with almost naked skin extending from the chin to the interramal tuft of vibrissæ.

Ears short.

Tail long, covering the scrotum and inguinal region, which are naked.

Legs and feet slender, interdigital cleft and back of pasterns almost naked, posterior side of legs below knees and hocks naked just above false hoofs, very scantily hairy elsewhere.

Penis complex, with a lamina normally folded up, beneath and behind the coiled terminal portion.

Genus Moschiola (Hodgson) Thos.

Body spotted and striped; mandibular white stripe moderately long, jugular very short; white on interramal area, throat and chest forming a wide continuous band.

No interramal gland, the interramal area covered with hair, from which the tuft of vibrissæ arises.

Ears short.

Tail very short, only covering the anus and leaving uncovered the scrotum and inguinal region, which are hairy.

Legs and feet slender, interdigital cleft and back of pasterns and posterior side of limbs below knees and hocks normally hairy, hairs on posterior side of metatarsal region growing upwards from a parting just above the false hoofs.

Penis simple, attenuated, spirally coiled distally, without lamina.

Genus Hyemoschus Gray.

Body spotted and striped; mandibular and jugular stripes long; white of throat continuous with that of interramal area and of chest.

No interramal gland, the interramal area covered with hair, from which arises the tuft of vibrissæ.

Ears long for the family.

Tail long, covering the scrotum and inguinal region, which are hairy.

Legs and feet stout and strong, interdigital cleft and back of pasterns nearly naked, posterior side of the limbs between the knee and hock and the false hoofs normally hairy, hairs on the back of the metatarsus forming a median crest, no parting above the false hoofs.

Penis simple, attenuated, spirally coiled distally; no lamina.

2. Report on Deaths of Animals in the Gardens in 1918. By J. A. Murray, M.D., Acting Hon. Pathologist to the Society.

[Received March 4, 1919: Read March 4, 1919.]

As in previous years the main facts of the mortality among the animals in the Society's Gardens are summarised in the Tables (I. and II.) given below. In birds and reptiles (including batrachians and fishes), the combined mortality statistics show practically no change as compared with 1917 and previous years. The higher mortality among mammals is mainly due to the admission during 1918 of a large number of young monkeys (*M. rhesus*) in which a heavy death-rate occurred. In addition, a considerable number of the more easily replaceable animals were sacrificed on account of the food-shortage occasioned by the war.

TABLE I.

MAMMALS.	BIRDS.	REPTILES AND FISHES.	
489	1496	310	In Gardens, 1.i.18.
659	176	314	Admitted in 1918.
1148	1672	624	TOTAL.
244 142 =386	50 325 =375	65 115 =180	Under 6 months. Over 6 months. Died.
33·6	22·4	28·8	Per cent. of total.
28·4	20·6	17·4	„ in 1917.
27·0	23·3	31·2	„ in 1911–15.

Table II. gives the distribution of the more important causes of death among the chief mammalian orders, in birds, and in reptiles, batrachians, and fishes. In the case of the primates a separate column has been reserved for the young *Macacus rhesus* admitted during the year. This has seemed advisable to avoid obscuring the details of the sufficiently severe losses among the other monkeys, many of which had been in the Gardens for years. In the case of acute infections of the respiratory tract, time has not permitted the accurate separation of the cases into lobar and broncho-pneumonia, capillary bronchitis, and acute congestion, and they are therefore all included under the one heading of pneumonia. The considerable numbers in which no diagnosis was made include, in addition to obscure cases, those which were not examined, or were too decomposed to allow of a satisfactory *post-mortem* examination.

TABLE II.

	MAMMALS.							BIRDS	REPTILES AND FISHES.
	M. rhesus, juv.	Primates.	Carnivora.	Rodentia.	Ungulata.	Marsupialia.	*Total.*		
1. *General Diseases.*									
Tuberculosis	15	11	6	2	1	...	35	50	4
Mycosis	...	...	...	...	...	..	...	4	2
Septicæmia	1	3	1	2	1	...	8	3	11
Abscess	1	...	4	...	1	...	6	2	3
Peritonitis	5	..	2	1	3	...	11	3	...
Helminthiasis }	44	...	1	...	...	.	45	5	6
Acariasis }		...	...	..	...	...		2	...
Anæmia	6	...	...	...	...	...	6	1	...
2. *Respiratory System.*									
Atelectasis	..	...	...	1	1	...	2	1	...
Pneumonia	85	34	12	13	16	1	161	98	15
Œdema of Lungs	1	...	...	...	..	...	1	2	...
Pleurisy }	7	...	...	...	...	...	7	3	...
Pericarditis }									
3. *Alimentary System.*									
Gastritis	...	...	...	...	...	1	1	...	...
Enteritis	7	4	6	6	4	...	27	62	3
Intestinal obstruction	...	...	...	1	...	...	1	3	1
Intussusception	2	...	...	...	...	1	3	...	...
Hepatitis	...	...	...	...	...	...	...	2	8
Pancreatitis	...	4	1	...	...	...	5	1	...
4. *Urinary and Generative Systems.*									
Nephritis	...	2	1	2	2	...	7	34	4
Cystitis	...	...	...	...	...	...	...	...	...
Ovaritis	...	...	...	...	...	...	...	...	1
5. *Various.*									
New Growth	...	...	1	...	...	...	1	2	...
Granuloma	...	...	...	...	...	...	...	4	2
Hæmorrhage	...	...	...	...	1	. .	1	8	2
Starvation and Malnutrition	...	...	...	..	...	...	...	4	25
Injuries discovered *post-mortem*	1	...	...	. .	...	...	1	...	1
Killed by companions, rats, &c.	...	...	...	...	...	...	...	19	2
Killed by order	...	...	13	...	4	...	17	5	...
Not diagnosed	23	7	3	2	4	1	40	58	89

Acariasis.—In addition to causing scabies when parasitic in the skin of mammals, parasitic mites also occur in the respiratory organs of birds with some frequency. The young Rhesus monkeys referred to above were almost invariably found to harbour these parasites in their lungs where they produced extensive lesions consisting in connective tissue overgrowth around the bronchi, local collapse of the lung, and sub-pleural dilatations of the bronchioles and alveolar passages. In these cysts the mature parasites are found, sometimes in large numbers. The excreta of the mites, which contain very resistant doubly-refracting crystals, seem to be the principal cause of the irritation. The majority of these monkeys also suffered from intestinal nematodes, of which an *Œsophagostoma* was the most frequent and caused damage of varying severity to the colon. The larvæ of this parasite apparently enter the body through the skin and encyst in the wall of the large intestine causing multiple hæmorrhages. When mature they burrow through into the lumen of the gut, and the passage thus afforded to the micro-organisms of the intestine occasionally leads to local and general peritonitis.

Atelectasis.—The two deaths in mammals ascribed to this cause both occurred in new-born animals and present no points of interest. The bird referred to this rubric was an adult Chilian Sea-Eagle, in which sudden death was produced by the valvular occlusion of the opening of an abdominal air-sac by a foreign body. Very few respiratory movements apparently sufficed to distend the air-sac and compress the lung above it so quickly and completely as to cause death.

Pancreatitis.—This condition, which is an extremely rare cause of sudden death in man, has been the cause of death six times—four times in monkeys, once in a bear, and once in a bird. In these, extravasations of blood of varying extent were found throughout the gland. In addition, evidence of old inflammatory changes have been found in the pancreas in a Californian Sea-Lion and in a Slender Dog. In the latter, the condition seems to have been due to stenosis of the pancreatic duct leading to accumulation of inspissated secretion in all its branches, and a very extensive overgrowth of the connective-tissue stroma of the gland. The cause of the disease in monkeys has not been cleared up and requires further study. The marine Carnivora apparently share the enhanced liability to this rare and dangerous disease with the Primates, a seal which died in 1917 showing it in the acute stage. The Sea-Lion mentioned above had apparently recovered from an attack.

New Growths.—Death could be ascribed to malignant new growths in three cases:—In a Golden Eagle a large teratoma of the testis, containing bone, islands of keratinising epithelium, and masses of eosinophile leucocytes, was the seat of a fatal suppuration. A Diamond Dove presented multiple white nodules of lymphosarcoma in the liver. A Racoon died from an enormous carcinoma of the thyroid gland. In none of these were metastases observed in other organs. In addition, new growths were observed in a number of animals dying from other causes. A carcinoma of the liver was found in a Marsh-Buck which died of septic pneumonia. This growth is interesting because it is identical in structure with a type of cancer common in the cow and sheep, and rare in other animals. A fibro-myoma, arising from the circular muscular coat of the large intestine, was discovered in a Hedgehog. It was loosely impacted in the pelvis, and death was due to tuberculosis of the lungs and not to the tumour.

Comparative Pathology of the Thyroid Gland.—The material examined during 1918 has confirmed and extended the observations reported last year on the thyroid. In consequence of the increased attention directed to this organ a number of cases of thyroid enlargement have been found and studied. Senile cystic goitre was observed in an Andaman Teal. In a Nutmeg Finch both thyroids were greatly enlarged, being twenty to thirty times the normal size. The microscopical appearance was that of exophthalmic goitre in man, the thyroid vesicles being filled with masses of proliferated epithelial cells and practically no normal vesicles with colloid could be seen. The Baska Tortoise which died in 1918 also showed an enlarged thyroid. The gland had undergone a tumour-like transformation, the epithelium of the dilated vesicles being folded into papillomatous outgrowths. The whole gland was increased in size, being three to four times as large as that of another tortoise of nearly the same weight. Neither in the Nutmeg Finch nor in the Baska Tortoise was there any record of symptoms during life which could be ascribed to the changes in the thyroid.

The accompanying table (Table III.) shows the influence of meat and vegetable diet on the size of the thyroid gland very clearly.

The animals are arranged in descending order as to weight and the Herbivora are all much heavier than the Carnivora placed against them. Nevertheless, the latter have the heavier thyroids with the exception of the Elephant-Seal and the Sea-Lion, which live on a fish diet. The contrast in size of thyroid between the Elephant-Seal weighing 950 lbs. and the Skunk weighing only 7½ lbs. shows that it is not a structural peculiarity of Carnivora as such, but a consequence of diet peculiarities, which manifests itself in this way. Similarly, the Bears, Cat-bears, and Coatis, which subsist on a mixed diet, do not show the massive thyroids of the strict Carnivores.

TABLE III.

CARNIVOROUS.		HERBIVOROUS.	
Elephant-Seal (950 lbs.)	14·5 g.	Eland	13·0 g.
Lion (500 lbs.)	40·0	Giraffe (juv.)	10·0
Tiger	24·0	Takin	9·0
Grizzly Bear	14·0	Zebra	6·0
Himalayan Bear	8·0	Anoa	5·0
Sea-Lion	11·0	Water-Buck	5·0
Leopard (33 lbs.)	7·0	Huanaco	2·0
Serval (15 lbs.)	2·5	Capybara	2·5
Skunk (7½ lbs.)	9·0	Porcupine (22 lbs.)	2·5

3. On a Collection of Fishes from Lake Tanganyika, with Descriptions of three new Species. By G. A. Boulenger, F.R.S., F.Z.S.

(Published by permission of the Trustees of the British Museum.)

[Received January 15, 1919: Read March 4, 1919.]

(Text-figures 1-3.)

When recently stationed in the Belgian Congo at Albertville, M. Dhont-De Bie, who accompanied the late Dr. L. Stappers on his Tanganyika-Mweru Expedition, made a collection of small fishes which has reached me through the kind mediation of Dr. L. Péringuey, Director of the South African Museum.

The collection, although a large one (1210 specimens), contains representatives of but comparatively few species, most of the specimens being referable to *Tilapia burtoni* (780), *Haplochilus dhonti* (210), and *Stolothrissa tanganicæ* (94). One species, *Mastacembelus mellandi*, is an addition to the fauna of Lake Tanganyika, being previously known from the Solwin River in Northern Rhodesia (Congo watershed), and three are here described as new.

The species represented are the following:—

Lepidosirenidæ. *Protopterus æthiopicus* Heck. (Albertville).

Clupeidæ. *Stolothrissa tanganicæ* Regan (Lukuga River).

Characinidæ. *Alestes vittatus* Blgr. (Albertville).

Cyprinidæ. *Barbus serrifer* Blgr. (Albertville), *B. tæniopleura* Blgr. (Albertville, Lukuga R.).

Cyprinodontidæ. *Haplochilus dhonti*, sp. n. (Lukuga R.), *H. pumilus* Blgr. (Albertville, Kalimié R., Lukuga R.), *Lamprichthys tanganicanus* Blgr. (Lukuga R.).

Cichlidæ. *Tilapia melanopleura* A. Dum. (Lukuga R.), *T. burtoni* Gthr. (Albertville, Kalimié R., Lukuga R.), *T. horii* Gthr. (Lukuga R.), *T. dardennii* Blgr. (Lukuga R.), *Petrochromis tanganicæ* Gthr. (Albertville), *Paratilapia lukugæ*, sp. n. (Lukuga R.), *Simochromis diagramma* Gthr. (Albertville), *Lobochilotes labiatus* Blgr. (Albertville), *Lamprologus dhonti*, sp. n. (Albertville), *Plecodus paradoxus* Blgr. (Albertville).

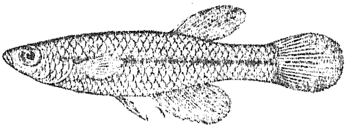
Mastacembelidæ. *Mastacembelus mellandi* Blgr. (Lukuga R.).

Descriptions of the new Species.

Haplochilus dhonti.

Depth of body $4\frac{1}{2}$ to 5 times in total length, length of head 4 times. Head flat above; snout shorter than eye; mouth directed upwards; lower jaw projecting; eye 3 times in length of head, ⅔ postorbital part of head, 1⅓ times in interorbital width; præorbital ⅓ diameter of eye. Dorsal 10, originating at equal distance from head and from root of caudal, above anterior third of anal, median rays longest, ⅔ length of head. Anal 14–15, rays as long as dorsals. Pectoral ⅔ length of head, reaching a little beyond root of ventral; latter small, nearer end of snout than root of caudal. Caudal rounded, as long as head. Caudal peduncle twice as long as deep. 29–31 scales in longitudinal series, 16 round body in front of ventrals; no lateral-line pits. A blackish lateral band.

Text-figure 1.



Haplochilus dhonti.

Total length 35 millim.

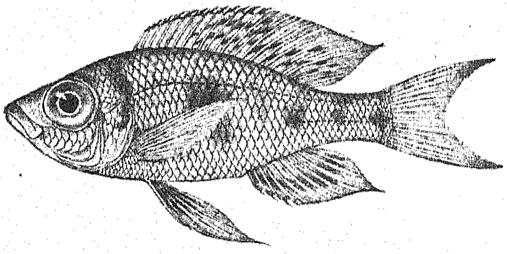
210 specimens from the Lukuga River.

The nearest ally of this species appears to be *H. myaposæ* Blgr., from Zululand.

PARATILAPIA LUKUGÆ.

Depth of body 3 to 3¼ times in total length, length of head 3 times. Head twice as long as broad; snout with curved upper profile, rounded, broader than long, as long as postocular part of head, shorter than eye, which is 2½ times in length of head, exceeds interorbital width, and equals 3 times præorbital depth;

Text-figure 2.



Paratilapia lukugæ.

mouth extending to below anterior border of eye; teeth very small, in 2 or 3 series; 2 series of scales on the cheek, width of scaly part $\frac{1}{3}$ diameter of eye. Gill-rakers rather long, 16 or 17 on lower part of anterior arch. Dorsal XI–XII 13–14; spines subequal from the sixth or seventh, which measures $\frac{1}{2}$ to $\frac{3}{5}$ length of head, and equals longest soft rays. Anal III 9; third spine $\frac{2}{5}$ length of head. Pectoral as long as head, extending a little beyond vertical of origin of anal. Ventral produced into a filament, which extends beyond origin of anal. Caudal with deep crescentic notch. Caudal peduncle $1\frac{1}{2}$ times as long as deep. Scales denticulate, 34–36 $\frac{3\frac{1}{2}-4}{14-15}$; lateral lines $\frac{24-30}{9-15}$, the upper extending to the caudal peduncle, or to the root of the caudal. Pale brown above, white beneath; 4 to 6 dark spots on each side, the first on the gill-cover, the last at the base of the caudal; dorsal and anal usually with dark spots or a dark longitudinal band, the rays tipped with black.

Total length 63 millim.

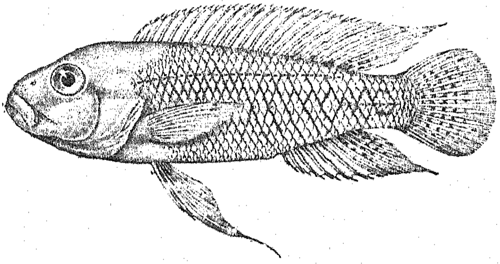
Several specimens from the Lukuga River.

Closely allied to *P. dewindti* Blgr.

LAMPROLOGUS DHONTI.

Depth of body $3\frac{2}{5}$ to $3\frac{3}{5}$ times in total length, length of head $2\frac{4}{5}$ to 3 times. Head twice as long as broad, with convex upper profile; snout rounded, $1\frac{2}{3}$ times as long as eye, which is 4 to $4\frac{1}{2}$ times in length of head and equals interorbital width; mouth not extending to below anterior border of eye; 6 rather large canine teeth in front of upper jaw and 4 in lower, followed by a moderately broad band of minute teeth; head entirely naked. Gill-rakers very short, 6 on lower part of anterior arch. Dorsal XVII–XVIII 8–9; spines increasing in length to the last, which is a little less than $\frac{1}{2}$ length of head; longest soft ray $\frac{2}{3}$ length of head. Anal V–VII 6–7; last spine $\frac{2}{5}$ length of head. Pectoral

Text-figure 3.



Lamprologus dhonti.

$\frac{2}{3}$ length of head. Ventral produced into a filament, extending beyond origin of anal. Caudal rounded. Caudal peduncle as long as deep. Scales 35–37 $\frac{6}{13-15}$; lateral lines $\frac{25}{8-9}$. Greyish, with a dark network on the body; soft dorsal and anal, and caudal with small dark spots.

Total length 65 millim.

Five specimens from Albertville.

This species should be placed between *L. mocquardii* Pellegr., from the Congo, and *L. tretocephalus* Blgr., from Lake Tanganyika.

4. On the Skull and Affinities of *Rana subsigillata* A. Dum.

By Miss JOAN B. PROCTER, F.Z.S.

[Received January 17, 1919: Read March 4, 1919.]

(Text-figures 1 & 2.)

Whilst making a study of the osteological characters in the genus *Rana*, it was pointed out to me by Mr. Boulenger that the skull of the West African *Rana subsigillata* A. Dum., to which he was the first to draw attention [*], might prove on closer examination to be of such special interest as to justify a detailed description. Mr. Boulenger, whom I have to thank for his kindness in giving me every facility to make this study, regards this frog as the monotype of a subgenus named by him *Aubria*. In his paper [†], "Aperçu des principes qui doivent régir la classification naturelle des espèces du genre *Rana*," some of the most striking characters of this frog are briefly noticed, and its position in the genus explained.

On raising the scalp, for a superficial examination, the skull is seen to approach that of *Rana* (*Pyxicephalus*) *adspersa* Tschudi in several characters, which will be enumerated later. It is strongly ossified, rather depressed, and broader than long, the general shape being typically frog-like. The interorbital portion of the brain-case is slender. Seen in profile, the cranium slopes upwards from the nasal region to a point in line with the posterior orbital borders, from which there is an abrupt decline to the *foramen magnum* (see text-fig. 1 *c*).

THE MEMBRANE-BONES OF THE CRANIUM.

The *nasals* are large, well-developed triangular bones, and somewhat rugose. They meet each other in the median line almost throughout their length, which is nearly two-thirds that of the fronto-parietals. Anteriorly each is obtusely pointed; posteriorly they form short oblique sutures with the anterior borders of the fronto-parietals, exposing in the centre a minute diamond-shaped area of the ethmoid. The distal ends do not reach the maxillæ proper, although they rest upon the maxillary processes in conjunction with the palatine cartilages.

The *vomers* are oblique, presenting an acute angle backwards and inwards, where they approach the proximal ends of the palatines, and the parasphenoid. Anteriorly they are deeply notched, the anterior processes reaching the maxillæ. These bones overlie the subnasal laminæ and the adjoining border of the ethmoid. The vomerine teeth are arranged in a simple line of four, springing from a prominent ridge on the outer oblique edge of each bone.

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[*] C. R. Ac. Sci. Paris, 165. (1917) p. 987.
[†] Bull. Soc. Zool. France, xliii. 1918.

The *fronto-parietals* are strongly ossified, and somewhat rugose on the anterior surface. The sagittal suture commences almost at their anterior extremities, but does not persist beyond a third of their length. Their combined width, anteriorly, is about a quarter of their length. At the postero-inner corner of the orbit they form small sharp projections, and then reach double the width. Posteriorly there is a slight sagittal crest, with two oblique lateral wings which form the commencement of the mastoid processes.

The *parasphenoid* is of the usual dagger shape, but rather more shapely than that of *R. temporaria*, and has an extremely tapering point. The lateral limbs of this bone are partially hidden beneath the superimposed inner limbs of the pterygoids.

THE CARTILAGE-BONES OF THE CRANIUM.

The *ethmoid*, as compared to that of *R. temporaria*, is elongated. In the specimen figured it is almost one-half the length of the entire skull. Anteriorly it is trilobate, or fleur-de-lys-shaped; dorsally this portion is overlain by the nasals, and ventrally the central lobe is partially obscured by the vomers and the proximal ends of the palatines. The main tubular portion of this bone, which reaches almost to the optic foramen, is covered by the fronto-parietals, but is visible on the ventral side through the semi-transparent parasphenoid. As already stated, only a minute diamond-shaped area of the ethmoid is exposed to view on the dorsal surface, where it is bounded by the postero-median notch between the nasals anteriorly, and by the antero-median notch between the fronto-parietals posteriorly. In the antero-inner corner of the orbit the ethmoid is pierced on each side by a small foramen for the orbito-nasal nerve.

The *prootics*.—The dorsal surface of each is largely covered by the inner branch of the squamosal, and its inner borders underlie the fronto-parietals. In the anterior wall below the flange of the fronto-parietals is the foramen for the fifth and seventh cranial nerves. The prootic forms the roof and the anterior wall of the auditory capsule.

The *exoccipitals* meet each other in the median line both dorsally and ventrally. The prootic-exoccipital suture proceeds along the crest of the mastoid process; the fronto-parietal-exoccipital suture is difficult to trace. Ventrally the anterior borders of these bones are bounded by the parasphenoid. The exoccipital condyles are well developed, and are visible from three aspects; at the base of each are two foramina, the upper minute and the lower larger and internally divided; these give exit to the ninth and tenth cranial nerves.

THE CHONDROCRANIUM.

The *nasal cartilages* consist of a roundly-pointed nasal roof above and a trifid sub-nasal lamina below.

Small triangular *prærhinals* are attached to the septum nasi.

The *palatine cartilages* extend from the ethmoid to the maxillæ, and are not peculiar in any way.

Owing to the thickness of the fronto-parietals and the extreme delicacy of the chondrocranium, I have not satisfied myself as to the size and exact positions of the fontanelles. It is clear, however, that there is a large median fontanelle, the anterior portion of which is bordered by the ethmoid, which at this point has a slightly bilobular tongue-shaped area carved out of it. The posterior wall of the otic capsule is cartilaginous; it is bounded by the parasphenoid below and by the prootic above.

The *columella auris* is strongly developed. The inter- and medio-stapedial portions are not unusual in any way; the extra-stapedial section is strongly developed and has a fan-shaped terminal of considerable size, which is applied in an inverted position to the tympanic membrane. The squamosal, at the junction of the interior limb with its stem, forms a deep arch over this delicate cartilage, and also gives support to the *annulus tympanicus*, which is somewhat funnel-shaped, broader than deep, and slightly notched above.

THE MAXILLARY ARCH.

The *palatines* are straight, semi-transparent bones, placed at right angles to the axis of the skull. They do not meet each other.

The *squamosals* differ widely from those of *Rana* (*sensu stricto*). They are enormously developed. The zygomatic branch, slightly rugose, forms a suture with the maxilla which is prolonged forward to the naso-palatine bar. This process tapers considerably at its anterior end, and is about half the length of the entire skull*; the suture is about four-fifths of this length. The inner limb, just over one-third the length of the zygomatic, with which it forms a right angle, is superimposed on the prootic, of which but a small border is exposed on each side. The posterior limb, or stem, of this bone is somewhat oblique, flat, and rounded at its distal end; it is applied to the pterygoid and the quadrate cartilage.

The *pterygoids* are the most remarkable bones in the skull. The inner processes overlap the lateral processes of the parasphenoid almost to their junction with the blade-like portion. At the junction of the anterior and posterior limbs, and opposite the root of the interior limb, is a large rounded process, which, when the skull is in its natural position, is directed outwards and downwards*; when the jaws are closed the outer face of this process is presented to the coronary process of the angulo-splenial, which it resembles in size and shape. This process seems to be very rare in the Anura, and until now has remained unnoticed.

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* Processes measured from their junction with the shaft of the bone, not from the right angle where they join each other.

The *quadrate cartilage* projects in two strong condyles, well beyond the extremities of the pterygoid, squamosal, and quadrato-jugal bones. It is of massive build, and in the specimen figured strongly ossified.

The *præmaxillæ* have rather long processes. Ventrally, at the suture which they form with each other, there is a shallow oval pit.

The *maxillæ* are wide, strong, and slightly rugose. Ventrally, and close to the sutures which they form with the præmaxillæ, are round shallow concavities. Posteriorly each is slightly bifid, the inner border of the inner limb completing the squamoso-maxillary suture, and the outer and longer branch forming a wedge-shaped suture with the quadrato-jugal.

The *quadrato-jugal* is a small short bone; its suture with the maxilla is very difficult to trace in old specimens.

THE MANDIBULAR ARCH.

Meckel's cartilage, where it articulates with the quadrate, ends in a prominent down-curved knob.

The *angulo-splenial* leaves much of Meckel's cartilage exposed to view; its coronary process is well developed, and, as before stated, lies face to face with the peculiarly similar process of the pterygoid, from which it is only separated by the *elevator temporalis* muscle.

The *dentary* at its distal end is raised into a slight tooth-like projection, which, when the jaws are closed, fits into the shallow pit at the anterior end of the maxilla which I have already mentioned.

The *mento-meckelian* bone forms a similar but larger projection which fits into the median pit situated across the præmaxillo-præmaxillary suture.

THE HYOID APPARATUS.

As will be seen from text-fig. 1 *d*, the hyoid apparatus, though differing slightly from that of *R. temporaria*, is not peculiar in any way.

SUMMARY AND CONCLUSION AS TO THE AFFINITIES OF *R. SUBSIGILLATA*.

From the above description it will be seen that the skull of *R. subsigillata* differs almost in every particular from that of *R. temporaria*, which, being the type of the genus, it is customary to take as a standard.

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* Owing to this oblique position it is slightly foreshortened in text-fig. 1 *a*, *b*; a better idea of its size can therefore be obtained from 1 *c*, where it is seen projecting below the maxilla.

Its most salient characters are:—

1. The prolonged squamoso-maxillary suture, a feature which it shares with *R. adspersa* alone. (See text-figs. 1 *a*, *c*; 2 *a*, *b*, *c*, *e*.)
2. The fourth pterygoid process, which it appears to share with *R. kuhlii* alone, although a faint indication of this process is sometimes met with in *R. adspersa*. (See text-figs. 1 *b*, *c*; 2 *d*.)
3. The marked overlapping of some of the membrane-bones, the most important of which are:—
   - *a*. The interior branch of the pterygoid on the transverse limb of the parasphenoid; an overlap only otherwise found in *R. adspersa*.
   - *b*. The interior limb of the squamosal on the prootic, as in *R. adspersa*, *R. grunniens*, *R. macrodon*, etc.
   - *c*. The nasals and fronto-parietals almost entirely obscuring the ethmoid, as in *R. adspersa* and *R. tigrina*. (Text-figs. 1 and 2.)
4. The slight pitting of the nasals, dorsal plane of the fronto-parietals, zygomatic processes of the squamosals, and the maxillæ; a character carried to excess in *R. adspersa*, in the adult of which these bones are covered with granular asperities. (Text-figs. 1 *a*, *c*; 2 *b*, *c*, *e*.)

As regards the squamoso-maxillary suture and the pterygoid overlap, it is an extraordinary thing that, whereas in no other species of the genus *Rana* are these characters exhibited even in old age, in *R. subsigillata* and *R. adspersa* they are well marked even in specimens under a year old, in which the frontals are still separated from the parietals (see text-fig. 2 *a*). This seems to me to greatly enhance the importance of these features, proving them to be no recent modification, and to isolate completely these two species among all others of the genus.

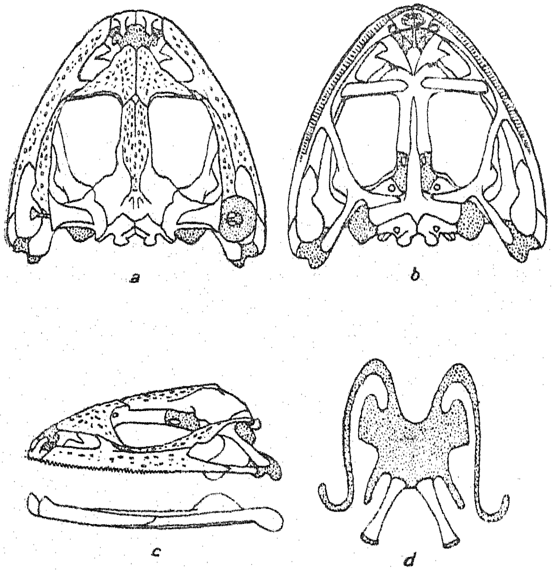
It is thus clear that the two species are closely related, a fact which seems conclusively proved by the development of the skull in the young *R. adspersa*.

Specimens of this frog at about one year of age (text-fig. 2 *a*) resemble in every cranial character the rather older young of *R. subsigillata*. They have the frontals yet separated from the parietals by oblique sutures; the sagittal suture is complete, and a moderate portion of ethmoid is exposed above. At this stage the skull shows no rugosities. At the age of about two years (text-fig. 2 *b*) the skull shows signs of pittings, and the fronto-parietals close in and expose slightly less of the ethmoid. At the age of about three years (text-fig. 2 *c*, *d*) the skull conforms so exactly to that of *R. subsigillata* that (except for the fourth pterygoid process) to describe it would be to recapitulate the greater part of this paper. It has, however, slightly longer and more closely-set præmaxillary processes, and consequently a more pointed nasal roof, less triangular nasals, less developed extrastapedials, and a less prominent quadrate.

In later life (text-fig. 2 *e*) the cranial characters of *R. adspersa* become more pronounced, the whole skull broadening and assuming a more convex and massive form, and the slight rugosities of the halfgrown becoming marked excrescences in old specimens.

Although, therefore, these two species differ so widely in the adult state, especially in external characters (such as general shape, glandular folds, metatarsal tubercle, etc.), they bear important fixed characters in common, which isolate them completely from all other species of the genus *Rana*. The subgenus *Aubria* Blgr. might therefore be united with the subgenus *Pyxicephalus* Tsch. In this I find that I am not much at variance with Mr. Boulenger, who has kindly allowed me to quote the following remarks from his unpublished monograph on the Frogs of Africa:—"Although I am at a loss to guess on what grounds Günther (Cat. Bat. Sal. p. 7) reached the conclusion, from the original description of Aug. Duméril, that *R. subsigillata* appears to belong to the genus *Tomopterna* (=*Pyxicephalus*), it is undoubtedly a fact that, in spite of its very different appearance, it is more nearly allied to *R. adspersa* (the type of *Pyxicephalus*) than to any other, as the cranial characters show."

Text-figure 1.

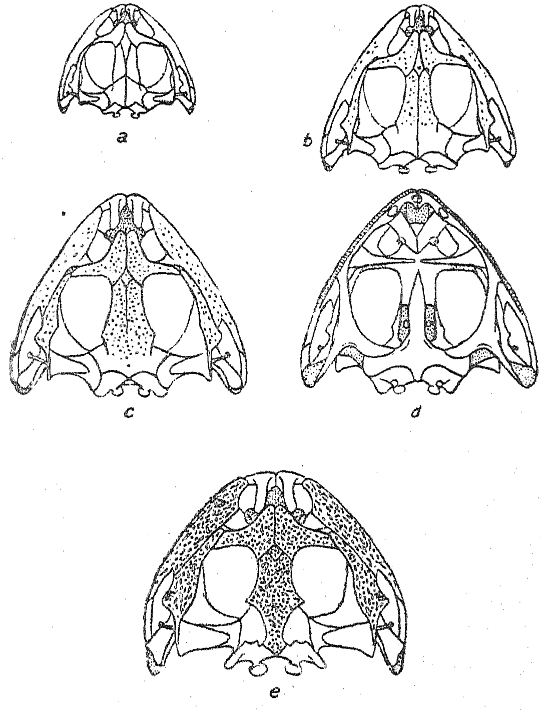


Skull of *Rana subsigillata*. (Nat. size.)

a. Dorsal view. *c*. Lateral view.
b. Ventral view. *d*. Hyoid.

After reviewing the cranial and other characters of these two species and comparing them with, for instance, those of *R. breviceps* and *R. delalandii*, it is indeed difficult to understand how the older authors (Tschudi, Duméril & Bibron, Günther, Peters, etc.) can have placed them together in one genus (*Pyxicephalus* or *Tomopterna*) merely on account of that worthless character, the shape of the metatarsal tubercle. On trying to make use of their comparative descriptions of *Rana* and *Pyxicephalus* one feels the need of applying St. Jerome's dictum: "Major styli pars quæ delet quam quæ scribit."

Text-figure 2.



Skull of *Rana adspersa*.

a. At about one year. Dorsal view. (Nat. size.)
b. „ „ two years. Dorsal view. (Nat. size.)
c. „ „ three years. Dorsal view. (Nat. size.)
d. „ „ three years. Ventral view. (Nat. size.)
e. Skull of an old specimen. Dorsal view. (Half nat. size.)

It seems probable that both species are derived from the *R. tigrina* group of *Rana*, *s. str.*, many points about the latter's skull confirming this view *.

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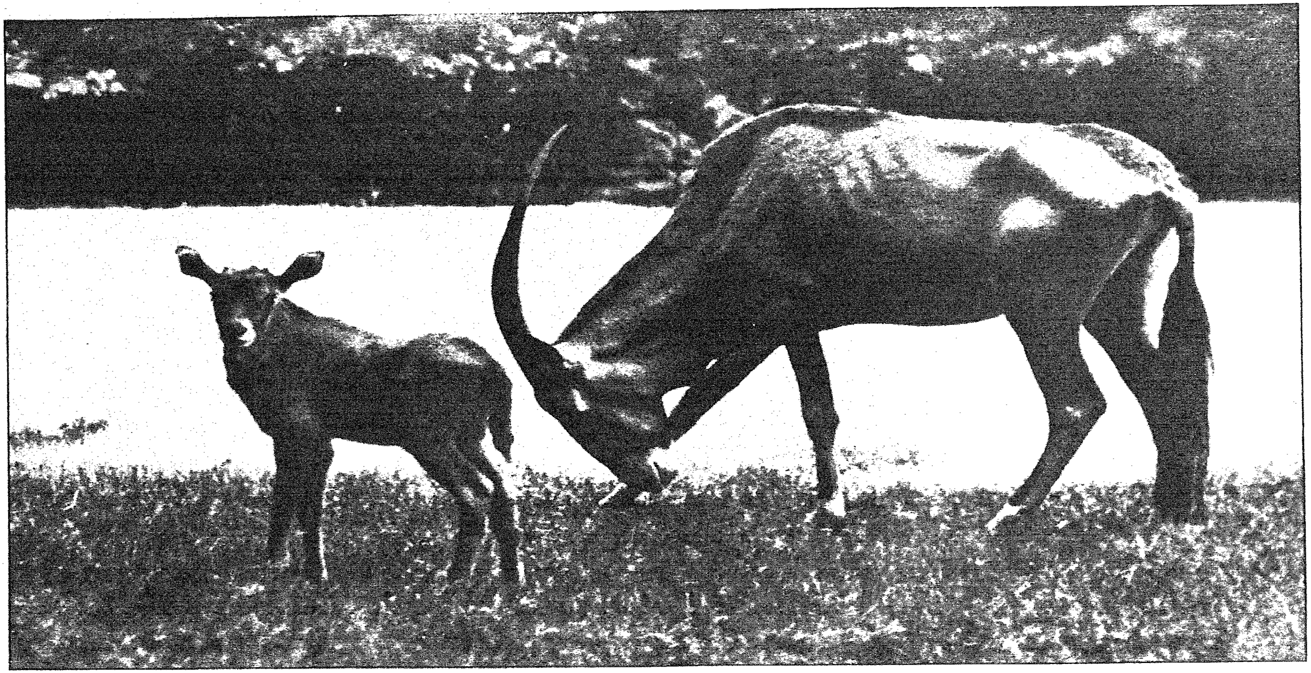
* The proportions and positions of the nasals, fronto-parietals, and ethmoid; length and strength of the zygomatic process of the squamosal; length of the inner limb of the pterygoid and its suture with the parasphenoid.



Young calf of *Oryx gazella* and adult female with abnormal horns.

5. On the Breeding of *Oryx gazella* at Gooilust.

By F. E. Blaauw, C.M.Z.S.

[Received February 20, 1919: Read March 18, 1919.]

(Plate I.*)

This species of Antelope is a scarce animal in Zoological Collections in Europe, and therefore some details about its breeding may be of general interest.

I got my pair in the summer of 1913, and although the importer was very mysterious about its origin, it soon became evident that the animals originated from the Kalahari, and had reached me via the Zoological Garden of Pretoria, where they had been kept some time.

During a trip to South Africa in the spring of 1914 I saw photos of animals of this species shot in German South-West Africa, and a settler from that country told me that *Oryx gazella* was fairly numerous in the southern parts of that colony to his own knowledge.

The pair of animals at Gooilust did extremely well, and I soon was able to let them out together in an enclosed field. Although they fought at first—and these fights looked rather formidable on account of the tremendously long and needle-sharp horns—I soon found that the fighting was more play than anything more serious, and so I could enjoy the sight of it without much apprehension.

The animals, although in perfect health, did not breed at first, and therefore, having the chance of obtaining another female in the spring of 1916, I acquired it. This female, although well built in other respects, had deformed horns, which were rounded as in *Oryx algazel*, so that I could not admire her very much. However, I put all three animals in the field, and during the course of the summer both females were covered by the male and became pregnant. In the spring of 1917 the female with the deformed horns, which had been looking in bad health for some time, gave birth to a dead calf which was nearly fully developed; and as she did not seem to recover entirely, I later on separated her from the others for fear of contagion.

On the 2nd of June of the same year my old female gave birth to a splendid calf, which appeared quite strong and well.

This calf may be described as follows:—

General colour a rufous sand-colour. A black tip to the tail. A dark streak from the eyes downwards, losing itself before reaching the bottom of the jaw. There is a black tip to the mane. The swelling which the adults have under the throat is very conspicuous in the newly-born calf, and the hair there is lengthened, forming a throat-mane. Inside of ears full of long hairs, forming a fringe which projects out of the ear-shell. On the outside margin of the ear a very thin black edge.

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* For explanation of the Plate see p. 30.

The horns became visible when the calf was three days old. Perhaps they were visible from the first, but as during the first two days I could not get near enough I cannot be positive about this.

At the age of six days, under certain lights, the black mark on the upper part of the fore legs of the adults became visible like a dark shadow, especially on the inner side of the leg.

At six weeks old some of the face-markings of the adults became slightly visible, and both the dark markings above the knee and hocks. Horns 4 inches long.

The calf did not follow the mother, as I have found so many of the larger antelopes do, but it kept itself hidden in a long tuft of grass as a fawn would do. From time to time the mother would come to it to give it milk, or if something came near that would frighten it, the calf would keep still until it was quite near, and then would make a sudden rush in the direction of its dam. When the object of its fright was gone, it would again hide, generally in the same tuft of long grass. Unfortunately, I have not been able to rear the calf to maturity.

In the second half of July the weather, which had been warm and dry, suddenly changed, getting cold and very wet. Of course, everything was tried to induce the animals to enter into their house, but it was several days before we succeeded. When at last it was accomplished, the old female was suffering from a slight diarrhœa, and after a couple of weeks it died. An attempt was made to rear the calf on cow's milk, but this was not a success, and on the 4th of August it died unfortunately. Although the immediate cause of death seemed to be the chill occasioned by the bad weather, I suspect the female with the abnormal horns, which got ill first, to have contaminated the herd, as after a while she, although not having been exposed to the bad weather, developed similar symptoms and died, and the same happened to the bull.

It was not possible to get a photo of the calf with its mother, as she would always put herself between the calf and the photographer.

It is, I suppose, unnecessary for me to say that *Oryx gazella* is one of the most beautiful antelopes in existence, and that every effort should be made to prevent this splendid animal being exterminated in its native country. In German South-West Africa these antelopes were preserved in large extents of country. I trust that under new rule the same excellent measures will continue.

These Antelopes are, I believe, still fairly numerous in some parts of the Kalahari, but I have not been able to ascertain that they are protected there. Measures in that direction would certainly be very welcome to all lovers of the splendid South African fauna.

EXPLANATION OF PLATE I.

Oryx gazella. Young calf and adult female with abnormal horns.

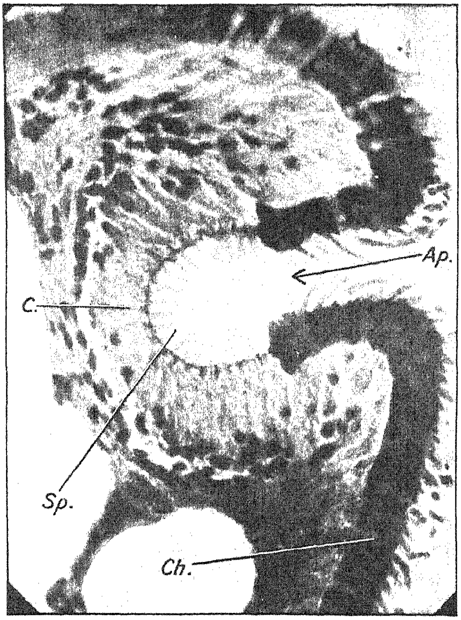

Fig. 1.

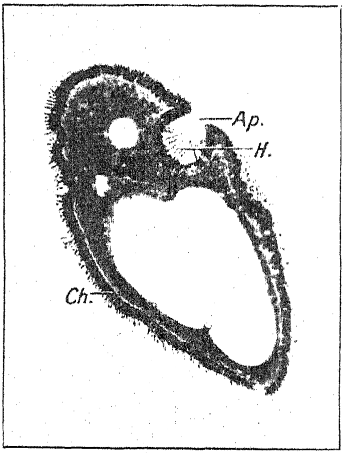

Fig. 2.

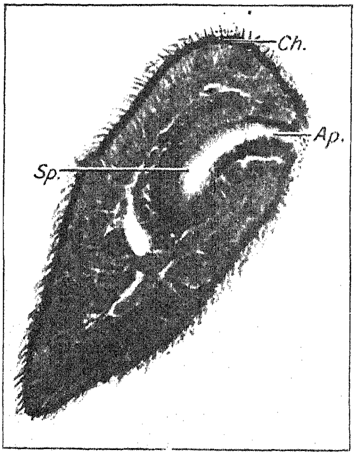

Fig. 3.

SENSE-ORGANS OF DIPTERA.

Bale & Danielsson, Ltd.

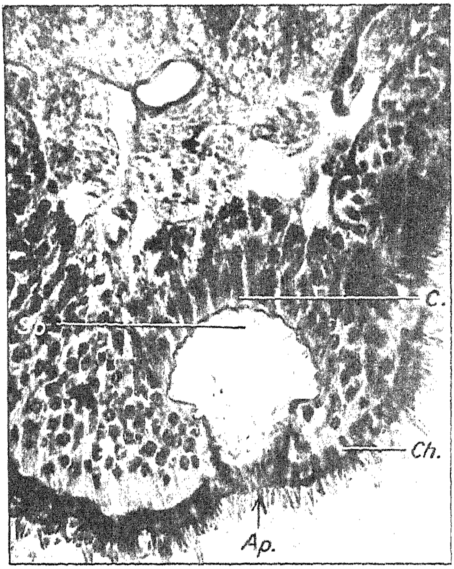

Fig. 4.

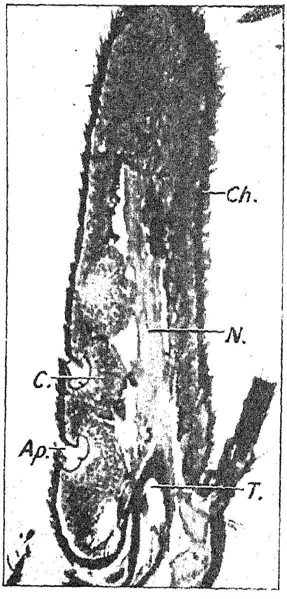

Fig. 5.

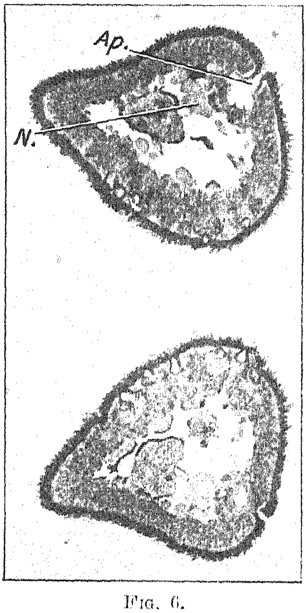

Fig. 6.

SENSE-ORGANS OF DIPTERA.

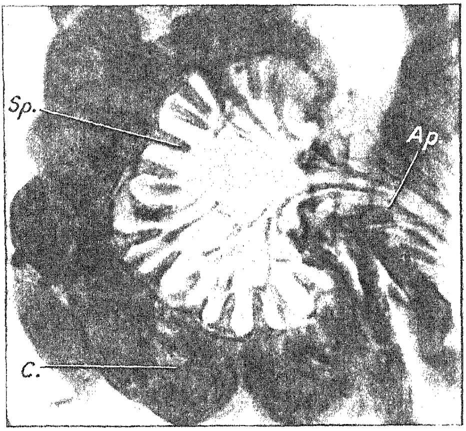

Fig. 7.

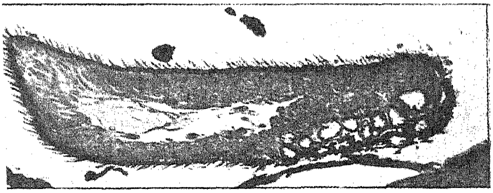

Fig. 8.

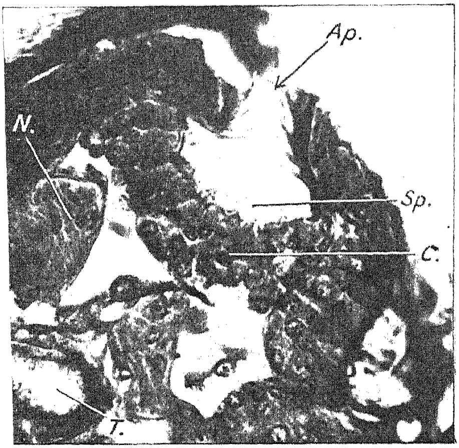

Fig. 9.

SENSE-ORGANS OF DIPTERA.

Bale & Danielsson, Ltd.

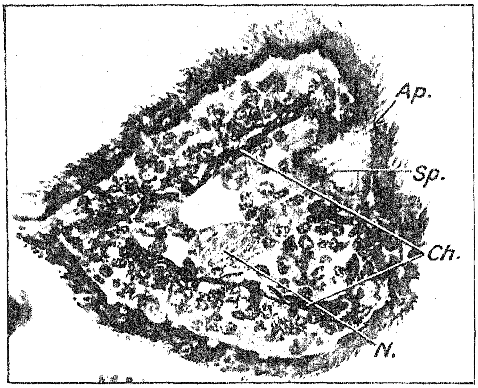

FIG. 10.

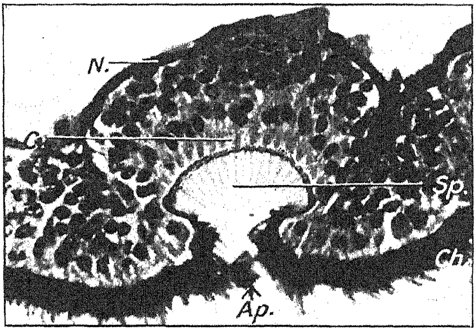

FIG. 11.

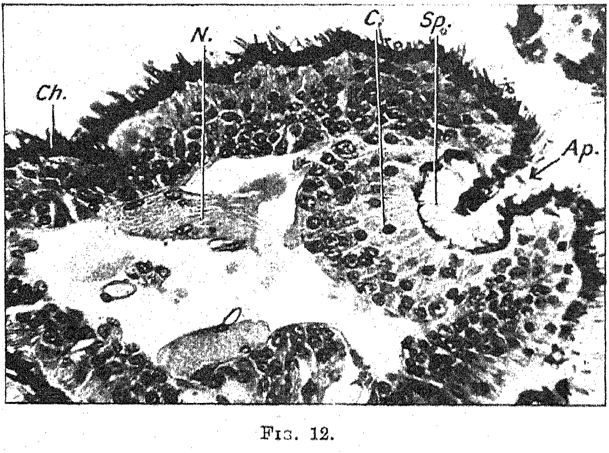

FIG. 12.

SENSE-ORGANS OF DIPTERA.

6. A Comparative Study of certain Sense-Organs in the Antennæ and Palpi of Diptera. By K. M. Smith, A.R.C.S., D.I.C.* With Appendix by Professor H. Maxwell Lefroy, F.Z.S.

[Received August 18, 1918: Read February 18, 1919.]

(Plates I.–IV. † and Text-figures 1–43.)

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(I.) Introduction.

This piece of work was begun at the suggestion of Prof. H. M. Lefroy and Mr. F. M. Howlett. It was originally to consist merely of a comparison of the antennal sense-organs of *Calliphora vomitoria* and *Musca domestica*, but was enlarged to cover as many types of Diptera as possible. It was decided to make a comparative study of these sense-organs in the different families and to correlate if possible their structure with the habits of the insects.

Several workers have picked out insects apparently at random and figured their antennal sense-organs, but so far as I am aware no one has yet made a systematic study and figured the type of sense-organ in each family. This I have endeavoured to do, and though it may not have led as yet to discoveries relating to the function of these organs, it should at least have some anatomical and histological value.

(II.) Material and Method.

All the specimens examined were caught by myself in this country. They were all taken alive and put direct into the fixative. Several fixing fluids were tried: Carnoy's Fluid, second formula (consisting of Absolute Alcohol 6 parts, Glacial Acetic Acid 1 part, Chloroform 3 parts), also Flemming's Fluid, Corrosive Sublimate, and Bouin's Fluid. The one that gave the best results was Carnoy's Fluid.*

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* Communicated by Prof. H. Maxwell Lefroy, F.Z.S.

† For explanation of the Plates see p. 69.

The entire insects, or, in the case of large flies, the head only, were left in this fixative for at least twenty-four hours, and were then washed thoroughly in 90 °/₀ alcohol. The heads were cut into longitudinal and transverse sections by the method of either double embedding in wax and celloidin or embedding in wax alone; for most purposes I found that wax alone sufficed. In this latter case, after washing well in 90 °/₀ alcohol to remove all traces of the fixative, the heads were left in absolute alcohol for twenty-four hours; they were then put into a mixture of equal parts of absolute alcohol and chloroform, thence into pure chloroform, thence into a mixture of chloroform and wax, and finally into pure wax. The changes must be as gradual as possible or shrinkage will occur. Much depends upon the time the object to be cut is left in the wax; the chitin will become hard and brittle if left in the wax too long, and a similar result occurs if not left in long enough. No definite time can be given; it varies from two hours with fragile insects to twenty-four hours or more with very large flies with thick chitin, such as Asilids or Muscids. 6 μ was found to be a good thickness at which to cut the sections, and all the drawings and photographs are made from sections of this thickness. Various stains were tried, those giving the best results being Delafield's Hæmatoxylin, Heidenhain, and Hæmatein. Most of the figures are drawn from sections overstained in Delafield's Hæmatoxylin and washed out in Acid Alcohol. All the drawings were made at the level of the microscope stage with the camera lucida at varying magnifications.

The great difficulty in carrying out this piece of work has lain in the tendency of the chitin, and with the chitin the delicate structures underneath, to break up under the razor; therefore a good razor with a good edge is essential, and a wax of medium hardness, melting-point 56° C., is the best. Owing to this difficulty it is necessary to cut very large numbers of sections and to select the best; over three hundred slides had to be prepared in order to obtain the results here given.

The species of flies examined have been exactly determined whenever possible. Owing, however, to various causes complete identification of the material has not always been feasible, and in some cases only the genus or family can be given. Acknowledgments are due to Mr. C. G. Lamb, to Mr. C. J. Wainwright, Mr. F. W. Edwards, and Rev. A. E. Eaton, for determining certain species. I desire to thank Mr. Hugh Scott for much useful assistance and advice, and Mr. Cecil Gunns, Chief Laboratory Assistant at the Imperial College, for his valuable help in making the photomicrographs.

(III.) General Description of the Sense-Organs under review.

The sense-organs of the antennæ and palps of Diptera here discussed * are composed of elements of the same general type as those described in many other insects. These elements consist each of a large, modified, hypodermal cell, above which is a very thin-walled chitinous process, rising from the thicker chitin of the general surface; and of a nerve-fibre, which runs close up to the base of, if not actually into, the chitinous process. The large cells were taken by some earlier writers to be nervous elements directly connected with the nerve-fibres, but Berlese (**1**) regards their function as glandular and considers that the nerve-fibres are in close apposition to, but not directly connected with, them.

Berlese (**1**) distinguishes several types of these chitinous sensory processes ("sensilli") including the following:—(i.) *Trichoid*, with the base sunk below the general surface of the chitin but with the apex projecting above; (ii.) *Basiconic*, arising directly from the general surface; (iii.) *Cœloconic*, with the base sunk in a pit and with the apex not reaching the level of the general surface. Wheeler (**2**) records the occurrence of all these types in ants. From my observations it appears that in many *Nemocera* the sensory processes are scattered singly on the surface and are referable to one or other of the above types. In some Psychodidæ a modification is found: the processes are very large and long, either spiral in form or bifid or triradiate, arranged in pairs, a single pair to each joint of the flagellum of the antenna (see text-fig. 3). In Cecidomyidæ also, there are peculiar "looped hairs" and other structures which may be modifications of simple sensory processes: see Felt (**3**), etc.

In the species of *Bibio* and the Mycetophilidæ which I have examined, and in all the other families of Diptera studied, there occur the compound sense-organs or "sense-pits" which are the special subject of this paper. These may be regarded as composed of a greater or smaller number of the sense-organs outlined above, united together, sunk in pits of very varying form or size, and modified in various other ways (see below).

In describing a typical sense-pit, Pl. IV. fig. 11 is a good example to take, being a photomicrograph of a transverse section of a sense-pit in the antenna of *Sarcophaga carnaria*, magnified about 600 diameters. There is first a somewhat large opening in the chitin leading down into the pit itself; in *Sarcophaga carnaria* this opening is wide and leads abruptly to the sensory processes, but in some species, *e. g.* certain Muscidæ, this opening leads into a long channel lined by chitin which sometimes exhibits spiral or convoluted folds or even a series of communicating ridges like basket-work (*Musca domestica*). The floor of the pit consists of a very thin chitinous membrane which is produced into the sensory processes much in the same fashion that fingers arise from a glove. These sensory processes vary much in shape; in the particular insect chosen as an example they are bottle-shaped, with the portion resembling the neck of the bottle produced to a great extent. In some cases the abrupt change from the thick surface chitin to the chitin lining the sense-pit is extraordinarily marked, *e. g.* Pl. I. fig. 1. Beneath the floor of the pit is a rounded mass of large radiating cells, each cell separating from its fellow as it approaches the base of the pit and running to its corresponding sensory process, see Pl. IV. fig. 11. The whole mass of cells is embraced by a branch of the large antennal nerve; this appears black in the photograph, Pl. IV. fig. 11, *N*.

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* No attempt is made in this paper to deal with the organs known as Chordotonal Organ or Johnston's Organ, situated near the base of the antenna in certain Diptera.

Although, as mentioned above, the view of most workers has been that these large cells are themselves nervous elements, Berlese (**1**) asserts that this is a mistaken view, and that they are glandular, while the nerve-fibres run between them. He says that they secrete a fluid which fills the sensory processes, comes through the chitin to the exterior, and bathes the whole surface of the pit. He quotes Von Rath as agreeing with this view, also Erichson (1847) and Sulcy (1891) as having affirmed the presence of a "humour" secreted osmotically. Packard (**4**) also states that these sensory processes are filled with a serous fluid and are definitely olfactory.

(IV.) Chief Modifications of the Sense-Pits.

As stated above, the sense-pits are modified in form in various ways. The following examples of this may be mentioned. In the Stratiomyidæ (text-figs. 10–12) the processes are in groups, each group arising from a common foundation, and having much the appearance of a partly closed hand. In the Syrphidæ the chief distinguishing feature lies in the large number of sensory processes and the great size of the pit; also in this family appears a further modification in that there are two kinds of pits, one consisting of a simple inpushing filled with coarse chitinous rods (Pl. I. fig. 2), and with few or none of the thin-walled sensory processes, the other consisting of the large and beautiful type of pit figured for many of the Syrphidæ, *Eristalis tenax*, *Xylota sylvarum*, and others. A somewhat similar difference in the size of the sense-pits occurs in the Muscidæ, and here also a further modification is found, namely in the fusion of three or four or sometimes more of the larger pits; *e. g.* Pl. II. fig. 5, in which the pits are double. In some species of the Muscidæ and some Anthomyidæ, the entrance to the pit is elongated into a channel whose wall consists of spiral folds or basket-work of chitin (text-fig. 38). The greatest variation occurs however in the size, shape, and number of the sensory processes themselves, which a glance at the Plates will at once make clear.

(V.) SITUATION OF THE SENSE-ORGANS.

In those families of Nemocera which have no antennal sense-pits, but only scattered sensory processes, these latter are found on a number, if not on all, of the joints of the flagellum. In the Bibionidæ, which have true pits, these were seen on a number of joints of the flagellum (as well as on the palpi: see below), but in the Brachycera and the Cyclorhaphous families antennal sense-organs were only observed on the terminal joint *. As to the palpi, pits were seen to be present on these organs in Mycetophilidæ, Bibionidæ, and Therevidæ; while special sense-organs of a somewhat different form are described in certain Stratiomyidæ, Asilidæ, and Dolichopidæ. Wesché (5) also describes pits in the palps of Rhyphidæ, Simuliidæ, Empidæ, and Pipunculidæ. He considers that when the antennal sense-organs are not highly developed, those on the palpi are so, to compensate for the deficiency. This is certainly true in some cases (*e. g.* certain Mycetophilidæ, Therevidæ, and the families alluded to by Wesché); but in some forms rather complex organs are present in both antennæ and palpi, *e. g.* in *Bibio marci*, certain Stratiomyidæ, Asilidæ, and Dolichopidæ.

(VI.) CORRELATION BETWEEN FORM OF SENSE-ORGANS AND HABITS OF THE FLIES.

It was hoped that after a systematic examination of the antennal sense-organs of the Diptera, some definite correlation between the form of these organs and the habits of the insect would be found. Such correlation, however, is not apparent. Wesché (5) mentions the case of *Gastrophilus equi*, the horse-bot, coming up against the wind straight towards a horse, and points out that this insect is well provided with antennal sense-organs; but so far as I have investigated, the Syrphidæ have by far the most complex and perfect sense-pits of all the Diptera, and it is not easy to see how their mode of life calls for this development. There is also the case of *Musca domestica* and *Calliphora vomitoria*; the former is supposed by some entomologists to find its food chiefly by sight and the latter chiefly by smell, yet there is very little difference in the antennal organs of the two, except that those of *M. domestica* are slightly more complex, though of course smaller in proportion.

In some flies possessed of very large eyes and keen sight, *e. g.* Asilids and Empids, the sense-organs seem slightly smaller, but in the case of the Muscidæ both eyes and sense-pits are large. The Asilids and Empids are predaceous, but their sense-pits show no apparent modification correlated with this fact. As to flies of parasitic habits, I have examined no Pipunculids, but Wesché (5) found in a species of this family no pits in the antennæ but a pit in either palp. In various Tachinids examined the pits are very similar to those of non-parasitic Muscids. Of the Hippoboscidæ, *Ornithomyia* appears to be poorly provided with antennal sense-organs, having only a few thin sensory processes sunk in shallow depressions, text-fig. 43.

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* The flagellar "complex" of the Brachycera is here treated as a single joint.

(VII.) FUNCTION.

At different times very many entomologists have attempted to settle the vexed question as to whether the antennæ bear the olfactory organs or no, by mutilation of the antennæ or by painting them with gum or some similar substances. It seems to me that experiments like this cannot definitely decide this question, relying as they do largely on statistics and there being of necessity so great an element of chance. McIndoo (**6**), in his paper on the olfactory sense of Hymenoptera, concludes that this sense must be looked for elsewhere than in the antennæ. He says: "It is seen that about one-quarter of all the workers who have experimented on insects with mutilated antennæ assert that these appendages do not bear the olfactory organs." On page 295 he states further: "It is now generally believed that the antennæ bear the organs of smell, but as all the antennal organs are covered with a hard membrane the objection has been raised that such organs cannot receive olfactory stimuli." I do not think the term "hard membrane" is applicable to the antennal organs of the Diptera at any rate, as the sensory processes in the pit are so excessively thin-walled as only to be visible under quite a high power of the microscope. Berlese (**1**) states that a fluid is secreted which passes through these processes and bathes the interior of the pit. Packard (**4**) also says that these processes are filled with a serous fluid and are definitely olfactory. Personally I have never been able to find any traces of this fluid.

W. M. Barrows (**7**), in his experiments on antennæ, found that gum on the antennæ of *Drosophila ampelophila* does not keep out odours. He etherised some flies and cut off the terminal antennal segment (and he declares that the ether did not affect his experiments). He writes:—"It seems certain that the sense of smell is absent or at least greatly reduced in those flies that have lost the *terminal* joint of the antennæ." I emphasize the word "terminal," because in all flies other than Nemocera it is only in the third (*i. e.* terminal) joint that the sense-pits occur. Wesché (**5**), who has studied this subject in some detail, writes: "A number of experienced entomologists have separately come to the conclusion that auditory organs exist in the antennæ of many species, and the deep pits or cavities in the antennæ of Muscids are thought to be such. This part then may be a tactile, an auditory, or an olfactory organ in different species, and it is probable that in many instances all three senses are located, perhaps not exclusively but in part, in the antennæ.

Further, I found on the third joint of the antennæ of *Gastrophilus equi* a larger number of sense-pits than on any of the flies mentioned (*Helophilus pendulus, Echinomyia fera, Thelaira nigripes, Calliphora erythrocephala, Stratiomys chamæleon*), and of a different structure." As to the pits of *G. equi* being of a different structure, I think Wesché is mistaken because, so far as I could determine, they were very similar to the sense-pits of other Diptera; they were certainly numerous, though not in my opinion as numerous as those of the Muscids. Wesché also says: "I think that when the antennæ are not particularly sensitive the palpi have these structures to compensate." This statement is borne out only partially by the results of my investigation (see above). Wesché states further: "We thus see that the palpi like the antennæ can bear organs of three senses—touch, taste, and smell, but I do not think that any one palpus has more than two of these senses developed at the same time." He concludes: "(i.) Both the antennæ and palpi of insects are capable of receiving the stimuli of several senses; (ii.) Their capacities differ greatly in different species and consequently a general rule is an impossibility."

Packard (4) states definitely that these organs are olfactory and agrees with Berlese (1) in saying that the pit is bathed in a fluid.

Wheeler (2) describes what he calls olfactory and gustatory sensilli on the third joint of the antennæ. He writes: "It seems to be impossible to distinguish between the sense-organs in insects, although it may be asserted that the organs of smell are situated mainly or exclusively on the antennæ, whereas those of taste are found on the mouth-parts, especially on the maxillæ and labium and their palpi." As stated above, I have not examined the organ situated near the base of the antenna in certain Diptera, known as the "Chordotonal Organ" or "Johnston's Organ" and which is regarded as auditory by most workers.

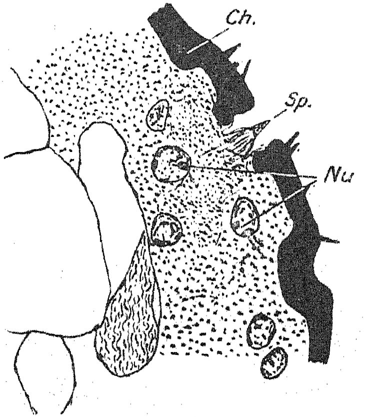
(VIII.) SYSTEMATIC DESCRIPTION OF THE SENSE-ORGANS IN THE VARIOUS FAMILIES.

ORTHORHAPHA. NEMOCERA.

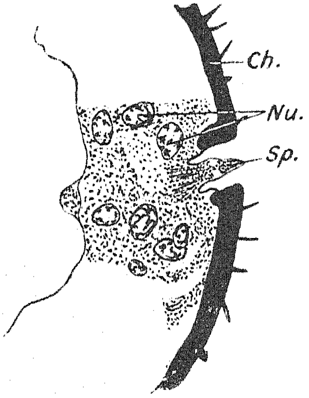
TIPULIDÆ (Text-figs. 1, 2). Species examined: *Pachyrrhina histrio* F. (C. G. Lamb det.), and one undetermined species. One kind of special sensory structure or "Sensillus" was found to be present; this is of the type described by Berlese (1) as "Trichoid," that is, sunk in a pit but projecting up to or beyond the general surface level. The shape of this sensillus varies slightly in the two species examined, in one case being narrowed to a point and having a distinct cap (text-fig. 1). The sensilli are scattered more or less indiscriminately over the surface of the antennæ. In the palps no particular sensory apparatus was apparent.

Packard (4) states: "The olfactory pits of Tipulids seem to have a different structure to those of the other Diptera as the external passage is closed." I think Packard is mistaken here, for my examination of the antennæ of the Tipulidæ revealed no pits at all but only the "Trichoid" sensilli of Berlese.

Text-figure 1.



Text-figure 2.



Transverse sections through the middle of the antennæ of an undetermined Tipulid and of *Pachyrrhina histrio.* × 980.

Except where otherwise stated, all the sections are through the third joint of the antennæ.

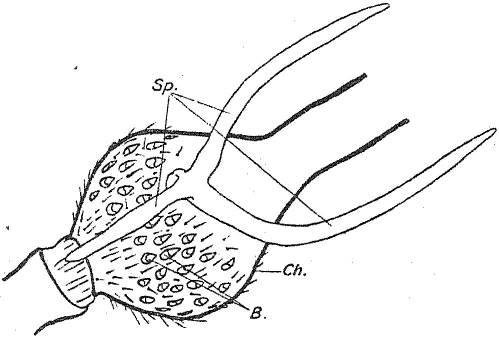
EXPLANATION OF LETTERING on the figures:—*Ap.*, aperture of pit: *B.*, base of hair; *C.*, cells; *Ch.*, chitin; *H.*, hairs; *N.*, nerve; *Nu.*, nuclei; *Sp.*, sensory process or sensillus; *T.*, top of second joint of antennæ.

PSYCHODIDÆ (Text-fig. 3). The form examined was *Psychoda albipennis* Zett., determined by Rev. A. E. Eaton.

In this insect the apparent sensory apparatus consists of a pair of pseudopodia-like processes on opposite sides of each joint of the flagellum. These processes are very large for the size of the insect and are triradiate. They are exactly comparable to the sensilli of Tipulidæ, consisting as they do of an outpushing of very thin chitin, only in this case they are carried to an enormous length and are three-branched. There is also a very thick ring of long hairs situated at the base of each joint. In text-fig. 3 only their bases (B) are shown so that they should not block out the triradiate processes. In the palps there is no special sensory apparatus visible.

Specialised processes or "chætæ" of this type have been described in several other Psychodidæ. In *Brunettia superstes* Ann., they are single, large, and spirally curved; and processes of this form are also present in several other species belonging to more than one genus (see Brunetti, 'Fauna of British India,' Dipt. Nematocera, 1912, pp. 198–9, 248, &c., and pl. 4). Eaton also refers to chætæ of somewhat the same type in *Telmatoscopus* *soleatus* (Ent. Mo. Mag. 1893, p. 126), and to S-shaped ones being present on each alternate joint of the flagellum of *Psychoda revisenda* (in litt., 23. ii. 1918). A pair of small bifid chætæ is present on each joint (except the last) of the flagellum in *Psychoda bengalensis* Brun., and *P. nigripennis* Brun. (see Brunetti, *op. cit.* p. 199), but no case of a triradiate process has hitherto been recorded. Some species of *Phlebotomus* also have pairs of shorter or longer geniculated spines on each joint of the flagellum (see Brunetti, *op. cit.* p. 200, and Newstead, Bull. Ent. Research, v. 1914, figs. 4, 9, 10, &c.).

Text-figure 3.

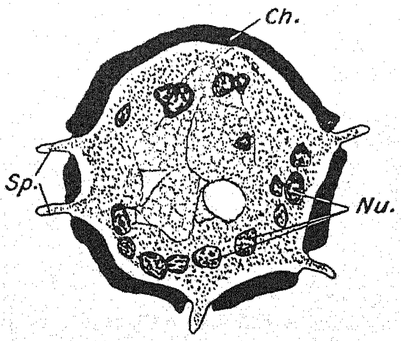


Segment of the flagellum of the antennæ of *Psychoda albipennis*, showing the triradiate process of one side in plan. × 980, from a whole antenna in cedar-wood oil.

CULICIDÆ (Text-fig. 4).

In text-fig. 4, which is a transverse section near the tip of the antenna of *Culex pipiens*, may be seen the sensilli, in this case not deeply sunk as in Tipulidæ, but of the basiconic type.

Text-figure 4.

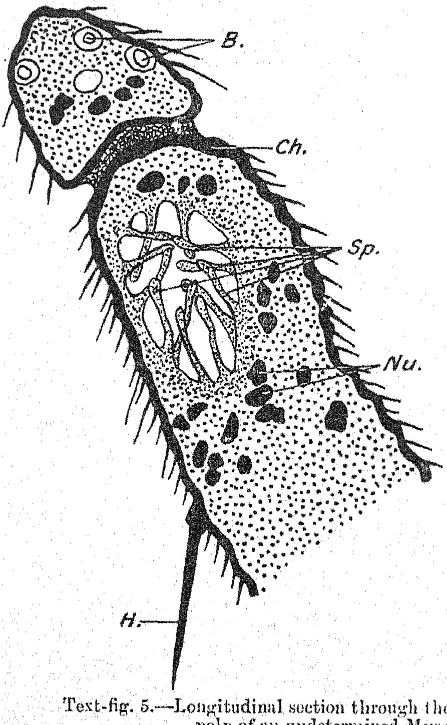


Transverse section through the middle of the antenna of *Culex pipiens*. × 980.

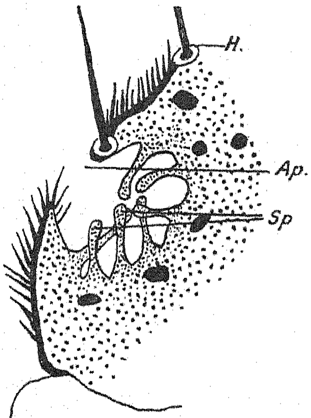
CECIDOMYIDÆ.

I have been unable to examine any of these insects myself, but Felt (**3**) describes the peculiar looped hairs or circumfili on the antennæ; he compares them to the "apparently fleshy hypodermal structures protruding from relatively large symmetrically placed orifices on the antennal segments of Campylomyzariinæ and of certain Chironomids." As I have not been able to examine any Cecidomyidæ I cannot speak with certainty, but possibly Felt is not quite correct in describing these processes as "fleshy hypodermal structures protruding from relatively large symmetrically placed orifices." What he takes for an orifice may be the sudden change from the thick chitin of the antennal surface to the excessively thin chitinous outpushing, which is comparable to one of the sensory processes of a sense-pit enormously enlarged. This sudden change from very thick to very thin chitin certainly gives the impression of an orifice, but under a high power it will be seen at once not to be so. I have not found any of these very large chitinous processes in the Chironomids, but they are very evident in the Psychodidæ (see above).

Text-figure 5.



Text-figure 6.



Text-fig. 5.—Longitudinal section through the first and second joints of the palp of an undetermined Mycetophilid. × 980.

Text-fig. 6.—Another view of the same. × 980.

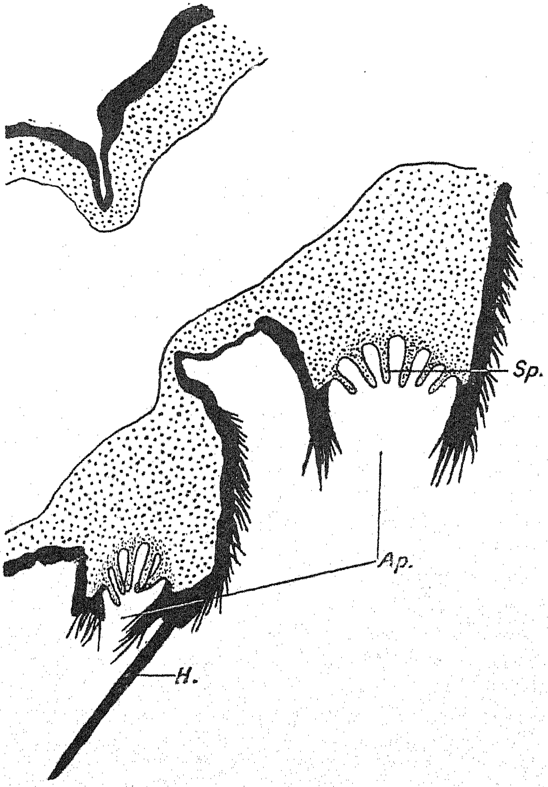
MYCETOPHILIDÆ (Text-figs. 5, 6).

Turning to the palps we find an entirely new modification of the sensilli; instead of occurring singly each one sunk in its own pit (Tipulidæ), or arising singly from the surface (Chironomidæ), they are grouped together and sunk in a large pit some distance below the chitin in the tissue of the palp. This is a "sense-pit," comparable to those of the later families. The pit lies in the second joint and there is one in each palp. The sensory processes are long and thin and spatulate. Text-fig. 6 is a drawing of a transverse section showing the pit and its opening; text-fig. 5 is from a longitudinal section, showing the pit but not its orifice.

BIBIONIDÆ (Text-figs. 7, 8).

In some species of this family the multiple groups of sensilli, or sense-pits, occur in both antennæ and palps.

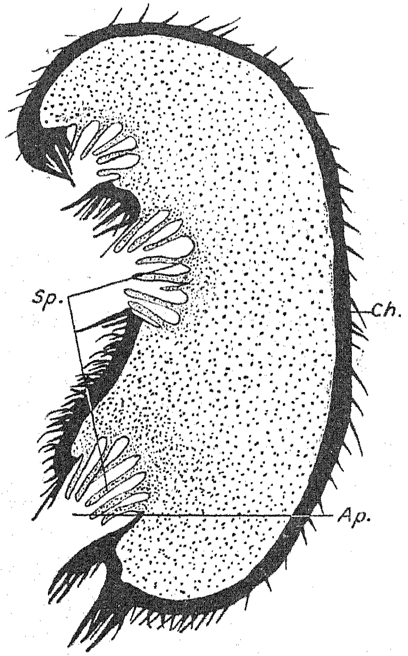
Text-figure 7.



Longitudinal section through the antenna of *Bibio marci*. × 600.

In *Bibio* sp. the sensilli in the antennæ, though increased in size, still occur singly or in pairs. Text-fig. 7 is a drawing of a longitudinal section of the antennæ of *Bibio marci* ♀; in this species sense-pits are present, though the sensory processes are not very numerous nor very deeply sunk, one sense-pit occurs in each segment of the antenna. In the palp the number of pits is greater, and most of the upper surface of the palp in the region near the head is broken up into sense-pits (text-fig. 8).

Text-figure 8.



Transverse section through the palp of *Bibio marci*. × 600.

Wesché (5) describes sense-pits in the second joint of the palpi of *Bibio hortulanus*.

SIMULIIDÆ.

I have not examined any members of this family, but Wesché (5) describes pits in the palpi of *Simulium reptans*.

RHYPHIDÆ.

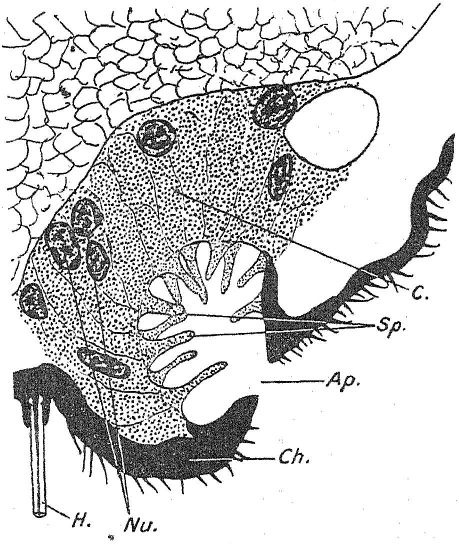
Wesché (5) describes sense-pits in the palpi of *Rhyphus fenestralis*.

ORTHORHAPHA. BRACHYCERA.

LEPTIDÆ (Text-figs. 9–16).

In *Leptis scolopacea* (C. G. Lamb det.) there are two types of sensory processes, large ones arising directly from the surface and smaller ones of somewhat irregular shape sunk deeply in pits and not reaching to the surface, *i. e.* the cœloconic type. In *L. tringaria* (C. G. Lamb det.) one type of sensillus only was seen, *i. e.* cœloconic. In the palp there is a well-marked sense-pit, and beneath it a mass of radiating cells with a few large nuclei (text-fig. 9). The sensory processes are long and somewhat spatulate.

Text-figure 9.

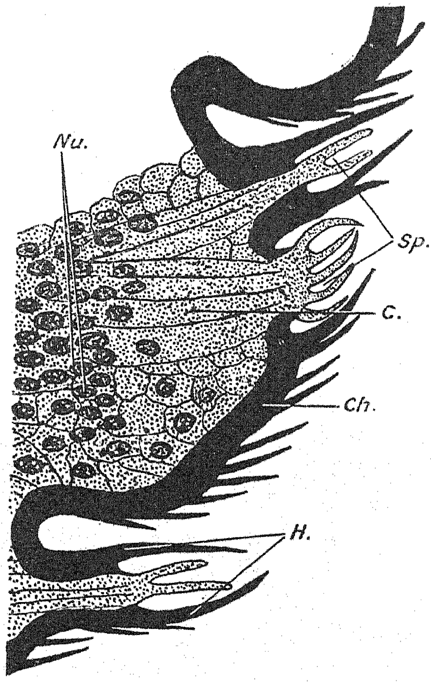


Transverse section of the palp of *Leptis tringaria*. × 980.

STRATIOMYIDÆ (Text-figs. 10–12). Species examined determined by C. G. Lamb.

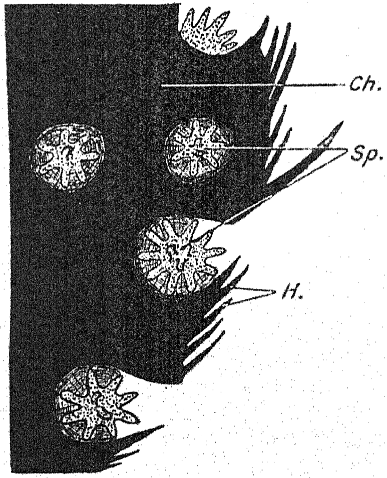
Text-fig. 10 shows a longitudinal section through one side of the antenna of *Oxycera trilineata* F. In this species there are not pits sunk below the surface, but groups of large sensory processes projecting above the chitin and protected by large and thick chitinous spines. These sensory processes resemble two hands placed palm to palm with the fingers directed slightly inwards; in some cases, however, there are only two or three processes. These "hands" are duplicated on the other side of the antenna.

Text-figure 10.

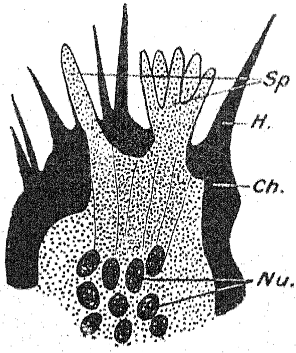


Portion of a longitudinal section through the antenna of *Oxycera trilineata*. × 980.

Text-figure 11.



Text-figure 12.



Text-fig. 11.—Portion of antenna of *Microchrysa polita* in plan. × 980.
Text-fig. 12.—Longitudinal section through the top of the palp of *Oyxcera pulchella*. × 980.

Text-fig. 11 shows a portion of the antenna of *Microchrysa polita* L., showing the "hands" in position; the thin chitin which forms the base of the structure is represented by cross-hatching.

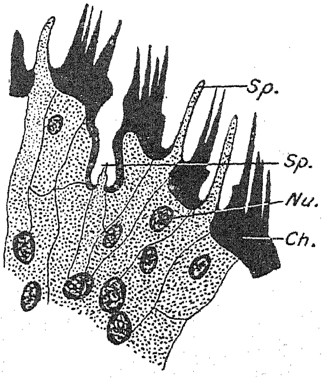
Much the same state occurs in the palp. Text-fig. 12 shows a longitudinal section through the top of the palp of *Oxycera pulchella* Meig., with one "hand" and one large single sensory process.

Wesché describes very similar sense-organs in the antennæ of *Stratiomys chamæleon*.

Tabanidæ (Text-fig. 13). Species examined determined by C. G. Lamb.

In the antennæ of the members of this family studied is found a return to the less complicated form of sensory structure. There are two kinds of processes, a large straight type sunk singly in a small pit, but projecting far beyond the level of the chitin (text-fig. 13): this is the trichoid type of sensory process. There are also small shouldered processes, sunk singly very deeply in the tissue of the antenna. There is little or no difference between the sensory processes of *Tabanus bromius* L. (♀) and *Hæmatopota pluvialis* L. (♀). I have been unable to find any special sensory structure in the palps of this family.

Text-figure 13.

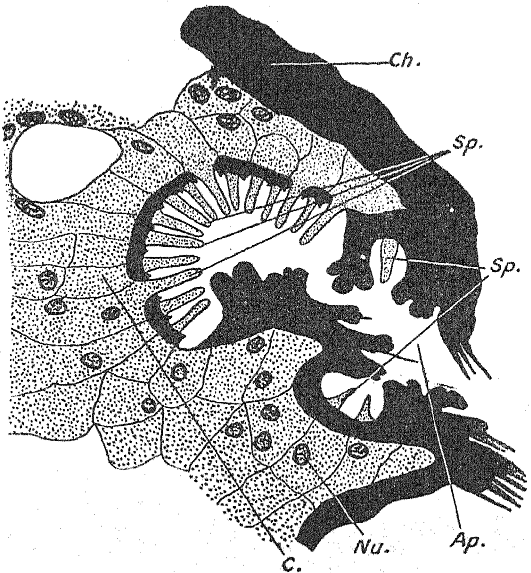


Part of a transverse section of the antenna of *Tabanus bromius*. × 980.

Asilidæ (Text-figs. 14–16). Species examined determined by C. G. Lamb.

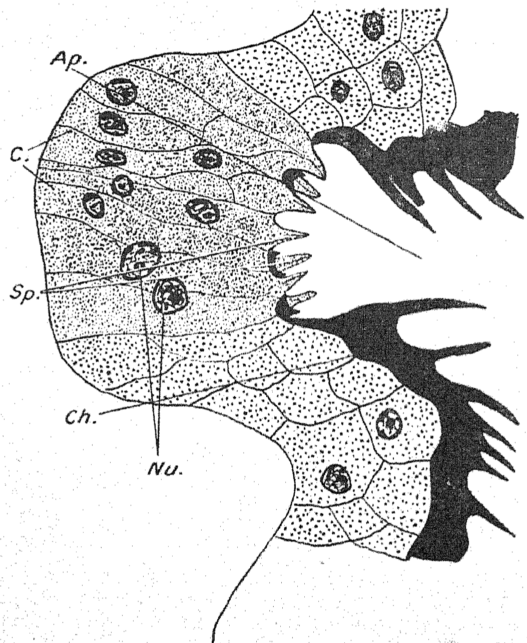
In this group we return once more to the actual sense-pit. Text-fig. 14 shows a longitudinal section through the antenna of *Laphria marginata*; the chitin is enormously thick and the entrance to the sense-pit is guarded by thick knobs and projections of chitin and interspersed with small pits containing one or more sensory processes of varying shapes. The processes in

Text figure 14.



Part of a longitudinal section through the antenna of *Laphria marginata.* × 980.

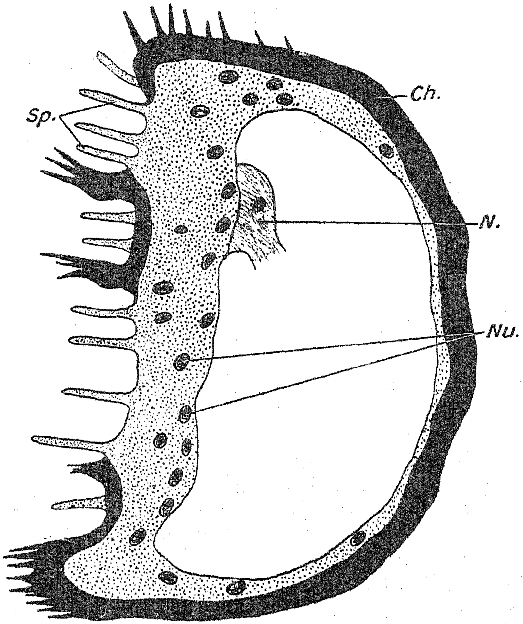
Text-figure 15.



Part of a transverse section through the antenna of *Neoitamus cyanurus.* × 980.

the pit itself are long and regular, each one rising from a thick chitinous ring or collar. Text-fig. 15, from a transverse section through the antenna of *Neoitamus cyanurus* Loew, shows a pit widely open to the exterior, with short strong processes each again rising from a collar, and having a ridge along its point. Note the bulge in the hypodermal layer formed by the columnar cells, called glandular by Berlese. Text-fig. 16 shows a transverse section through the palp of *Laphria marginata* L.; the whole of one surface is broken up into long slender processes, not sunk in pits but arising directly from the surface. Note the thickness of the chitin in these insects.

Text-figure 16.



Transverse section through the palp of *Laphria marginata*. × 980.

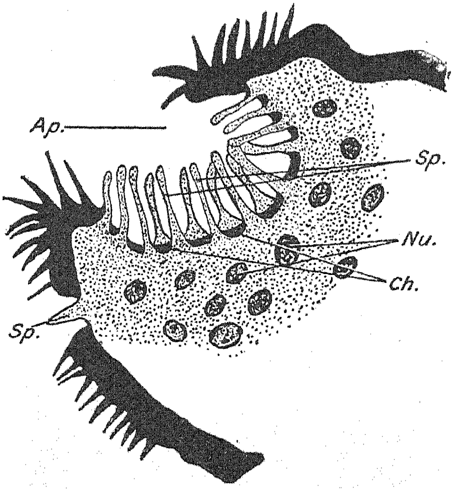
THEREVIDÆ (Text-fig. 17).

There are, so far as could be ascertained, no pits in the antenna in this family. In the palp of *Thereva nobilitata* (text-fig. 17) is a more complicated condition. There is a large sense-pit widely open to the exterior, with long spatulate sensory processes; also here and there are single trichoid processes.

EMPIDÆ. Species studied determined by C. G. Lamb.

So far as could be ascertained there are no complicated sense-pits in the forms examined. No special sensory apparatus was visible in the palps of species examined.

Text-figure 17.

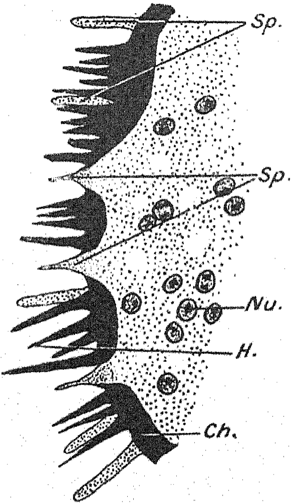


Part of a transverse section through the palp of *Thereva* sp. × 980.

Wesché (5) describes a large sense-organ on the palpi of an Empid, *Ocidromia glabricula*. This species I have not examined.

Dolichopodidæ (Text-fig. 18). Species studied determined by C. G. Lamb.

Text-figure 18.



Part of a transverse section through the antenna of *Pœcilobothrus nobilitatus*. × 980.

Text-fig. 18 shows a drawing of a portion of a transverse section of *Pœcilobothrus nobilitatus* L. Two distinct kinds of processes are present, large finger-shaped processes scattered in large numbers on the surface, and a smaller kind broad at the base and tapering to a fine point. Turning to the palp, there are again no pits and only one type of sensory process, this is in the shape of a curved finger. In *Dolichopus brevipennis* Meig., the sensory apparatus was very similar.

CYCLORHAPHA. ASCHIZA.

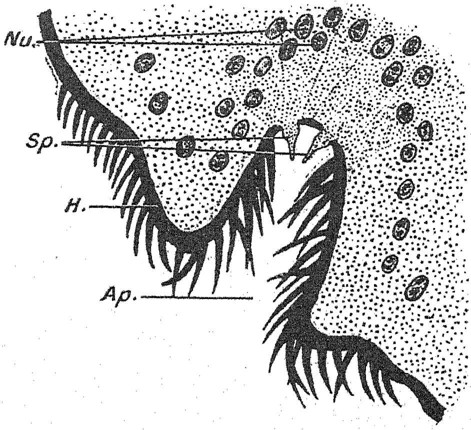
PIPUNCULIDÆ.

I have not had the opportunity of examining this group, but Wesché (5) describes *Pipunculus zonatus* as having small and characterless antennæ but a well-marked sense-organ in the tip of each palp.

SYRPHIDÆ (Text-figs. 19–27).

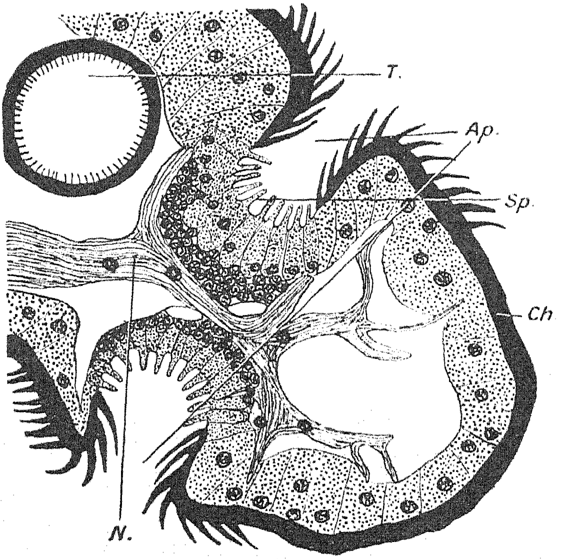
This is by far the most interesting family of all the Diptera, so far as the sense-pits are concerned. The Syrphidæ show an enormous specialisation in the shape and complication of their sense-pits, and the pits in different species of the family show a wide differentiation. All sensory processes and sense-pits are confined to the antennæ, none being present in the palpi, so far as could be seen. Text-fig. 19, part of a transverse section of the antenna of *Syrphus* sp., shows a somewhat deeply sunken pit lined at each side with stiff chitinous hairs; at the base are two bottle-shaped processes.

Text-figure 19.



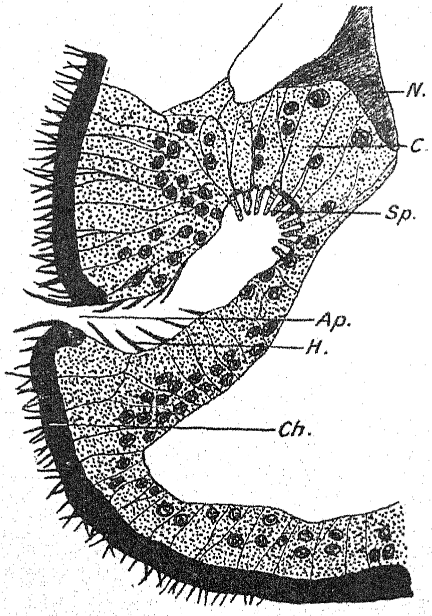
Part of a transverse section through the antenna of *Syrphus* sp. × 980.

Text-figure 20.



Transverse section of the antenna of *Rhingia campestris*. × 600.

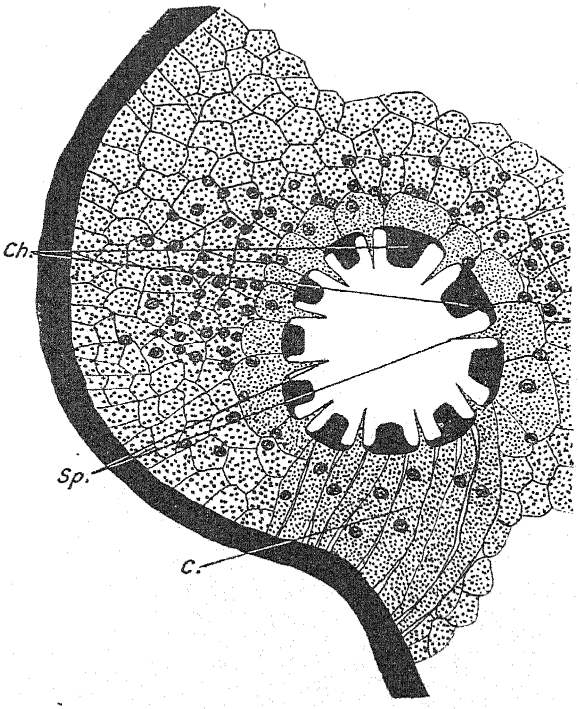
Text-figure 21.



Transverse section of antenna of *Volucella bombylans*. × 600.

Text-fig. 20, from a transverse section through the antenna of *Rhingia campestris* Meig., near the articulation, shows two sense-pits, one on each side of the antenna; they are widely open and are guarded by stiff hairs, the sensory processes are small and regular. The bases of the pits approximate very closely to each other and are separated by a large branch of the antennary nerve which closely embraces each pit. In *Volucella bombylans* (text-fig. 21) only one kind of sense-pit is found; this has a somewhat narrow opening and is deeply sunk, the channel is guarded by a few stiff hairs and the sensory processes are small and regular. Text-fig. 22 shows a drawing of a transverse section of the antenna of *Volucella inanis*. The section does not pass through the opening of the pit. The processes here are of a different type, they are rather short and sharply pointed, broadening towards the base, and each process is separated from its fellow by a large knob or block of chitin: *cf.* Röhler on *Volucella* (**8**).

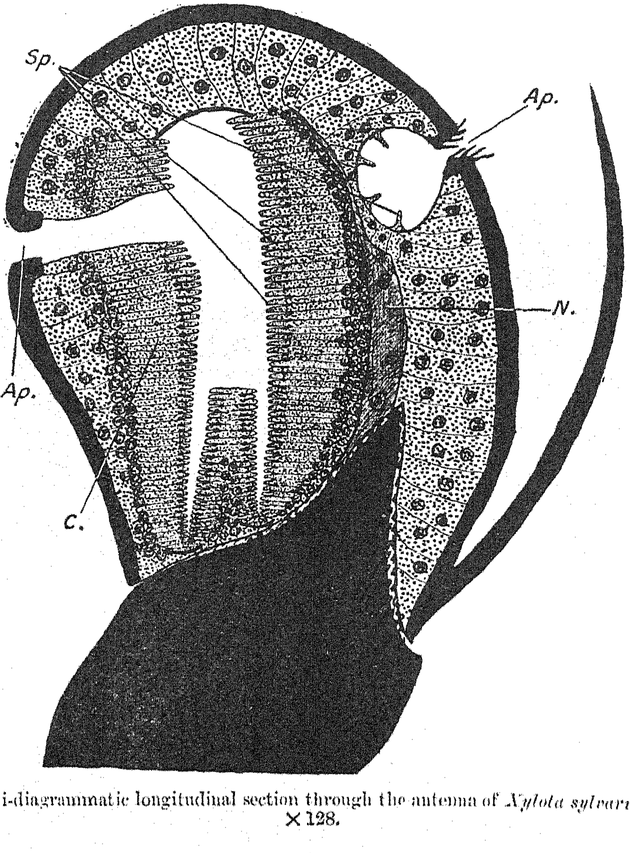
Text-figure 22.



Transverse section through antenna of *Volucella inanis*. × 600.

We come now to *Eristalis tenax*, the Drone Fly; this is a very interesting case, possessing as it does two types of sense-pits utterly different from each other. One type may be called the Complex Pit and the other the Simple Pit. Pl. I. fig. 1 is from a photograph of the former. It illustrates the very abrupt ending of the thick chitin and the very regular shape and character of the whole sense-organ. Each cell can be seen running up to its corresponding sensory process, and the whole organ is isolated by a space running round the base of the cells and cutting it off from the rest of the tissue. Pl. I. fig. 2 is from a photograph under a low power of the simple type of pit. It is merely a large in-pushing of the chitin widely open to the exterior, and instead of the delicate sensory processes found in other sense-pits, there are large and coarse rods of chitin. Also there is no abrupt thinning

Text-figure 23

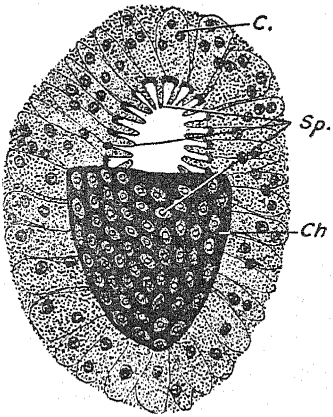


Semi-diagrammatic longitudinal section through the antenna of *Xylota sylvarum*. × 128.

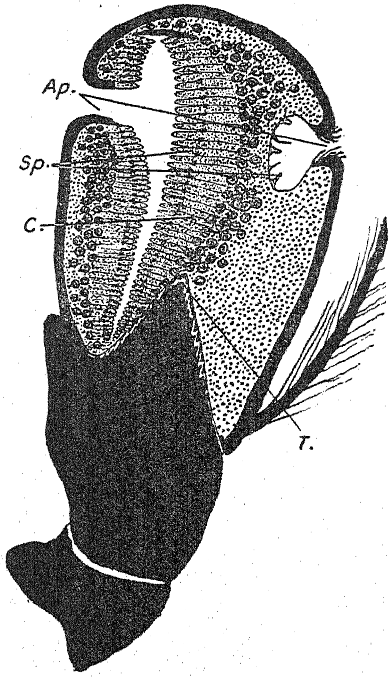
of the surface chitin but it continues round the base of the pit unchanged.

Turning to another species, *Xylota sylvarum*, a somewhat similar condition is found. In this case, however, the simple pit has no rods of chitin inside, but a few small sensory processes, and is comparable to the sense-pits in many of the foregoing families. The complex pit of *Xylota*, however, is very large and beautiful; it possesses an enormous number of sensory processes

Text-figure 24.



Text-figure 25.

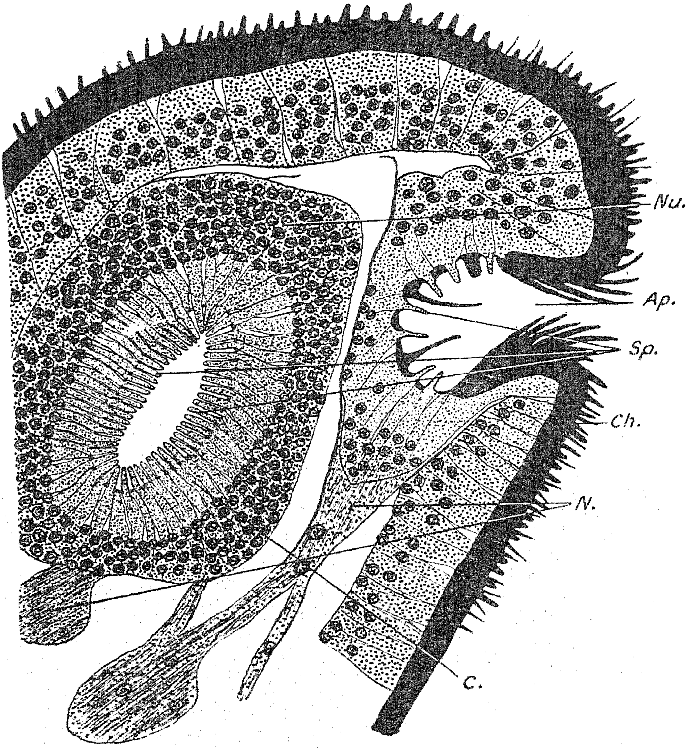


Text-fig. 24.—Oblique section through the top of a sense-pit in the antenna of *Xylota sylvarum*. × 980.

Text-fig. 25.—Semi-diagrammatic longitudinal section through the antenna of *Sericomyia borealis*. × 128.

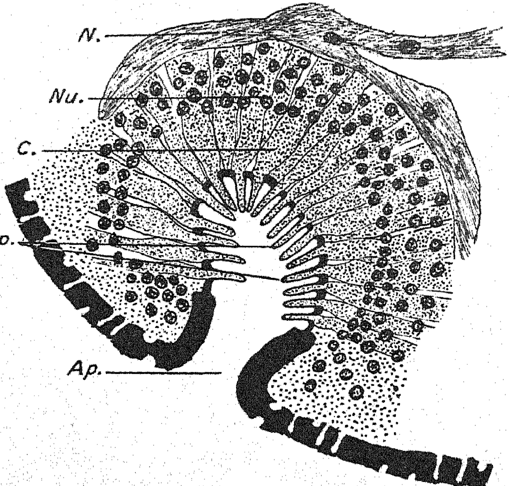
and almost fills the third joint of the antenna. Text-fig. 23 is a semi-diagrammatic representation of a longitudinal section of this joint. On the left side of the figure will be seen the large and beautiful pit with its opening and opposite to it the small pit. As the large pit is followed downwards it is seen to divide into two; the chitinous lining of the pit thickens between the processes. Pl. I. fig. 3 is from a photograph of a transverse section

Text-figure 26.



Transverse section of the antenna of *Sericomyia borealis*. × 600.

Text-figure 27.



Another transverse section of the same. × 600.

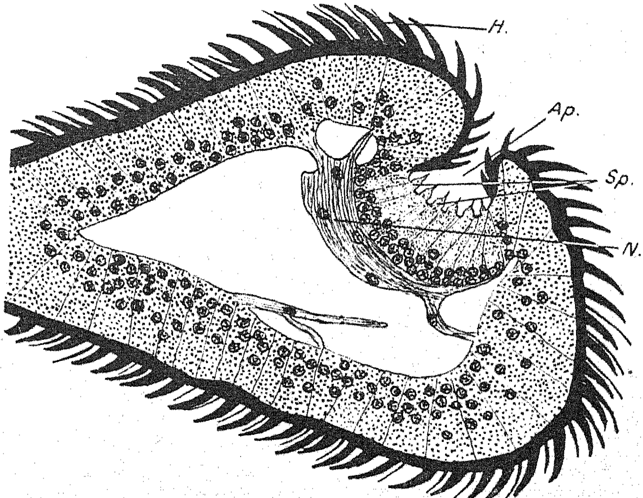
through the antenna of the same insect, taken under a low power. It illustrates how far the pit extends into the antenna and the large number of chitinous processes. Text-fig. 24 is an oblique section through the roof of the pit slicing partly through the chitin and exposing the pit itself. The chitin is perforated and through each perforation can be seen a sensory process. *Sericomyia borealis* shows a somewhat similar condition. Text-fig. 25 is a semi-diagrammatic representation of a longitudinal section through its antenna. The only difference from the condition in *X. sylvarum* lies in the fact that the pit does not bifurcate. Text-fig. 26 is from a transverse section of the antenna of *S. borealis*, showing the large pit dissociated from the rest of the tissue, with a cell running to each process. The pit is surrounded by a nerve and all the nuclei are confined to the parts of the cells remote from the sensory processes. Text-fig. 27 is a section through the opening of the large pit and the nerve is shown encircling the large cells.

CYCLORHAPHA. SCHIZOPHORA.

SEPSIDÆ (Text-figs. 28, 29.)

Text-fig. 28 is a drawing of a transverse section of the antenna of a large undetermined Sepsid showing a sense-pit with its large cells and the nerve encircling them. The sensory processes are bottle-shaped and drawn out to a point. Text-fig. 29 is a semi-

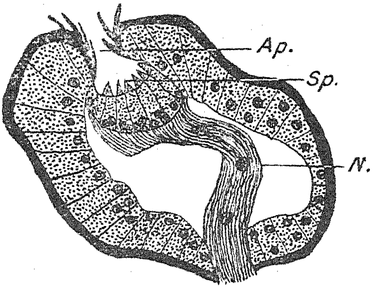
Text-figure 28.



Transverse section through the antenna of an undetermined Sepsid. × 600.

diagrammatic drawing of a longitudinal section through the antenna of a smaller Sepsid, showing the very large nerve running to the sense-pit. The sensory processes are triangular.

Text-figure 29.

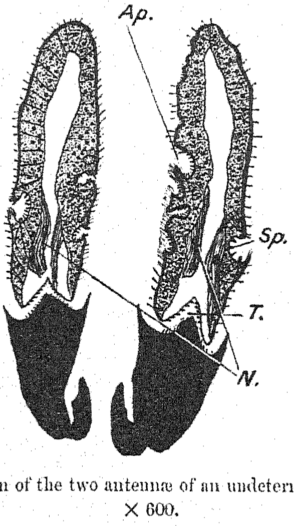


Semi-diagrammatic longitudinal section of the antenna of a small undetermined Sepsid. × 600.

SAPROMYZIDÆ (Text-fig. 30).

Text-fig. 30, longitudinal section of the two antennæ of *Sapromyza* sp. On the outside of each antenna is one large widely

Text-figure 30.



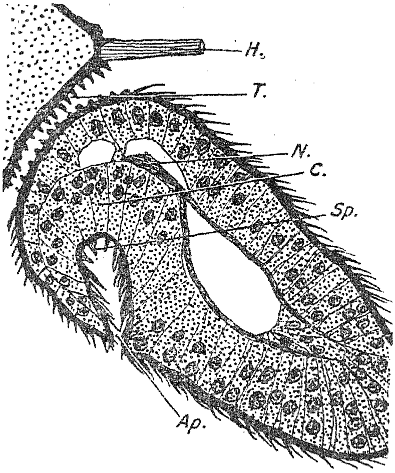
Longitudinal section of the two antennæ of an undetermined Sapromyzid. × 600.

open pit, and on the inside of each a number of rather irregularly shaped pits grouped somewhat closely together. The figure shows the large nerves running to the pits.

OPOMYZIDÆ (Text-fig. 31).

Text-fig. 31 is a longitudinal section of an antenna of *Opomyza germinationis* (F. W. Edwards det.); there is one sense-pit, rather long and narrow, lined at the sides with stiff hairs and having a few sensory processes at the bottom.

Text-figure 31.

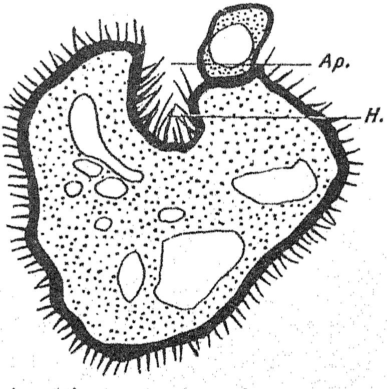


Longitudinal section of antenna of *Opomyza germinationis*. × 600.

CHLOROPIDÆ (Text-fig. 32).

Text-fig. 32 shows a transverse section of the antenna of an

Text-figure 32.



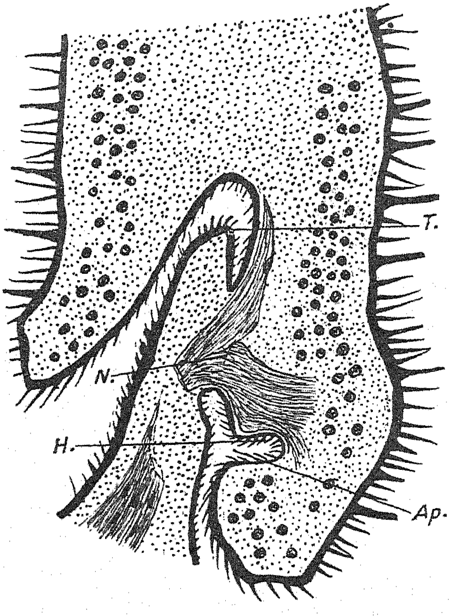
Transverse section of the antenna of an undetermined Chloropid. × 600.

undetermined Chloropid. I have been unable to find any of the true sense-pits in this species, and there appears to be only one inpushing of the chitin filled with stiff hairs.

HELOMYZIDÆ (Text-fig. 33).

The general surface of the antenna of *Tephrochlamys rufiventris* is beset with large finger-like sensory processes spread about in great profusion and interspersed between very large chitinous spines. Text-fig. 33 is a longitudinal section through the second and third joints of the antenna of the same insect showing the antennary nerve passing from one joint to another and also a pit of simple type.

Text-figure 33.

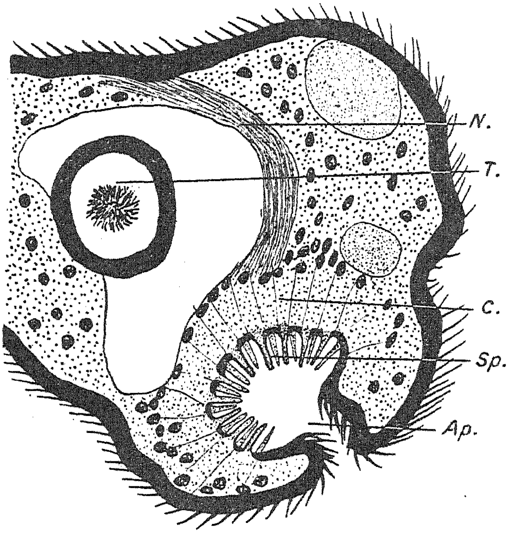


Longitudinal section through the second and third joints of the antenna of *Tephrochlamys rufiventris.* × 600.

CORDYLURIDÆ (Text-fig. 34).

Text-fig. 34, from a transverse section through the base of the third joint of the antenna of *Scatophaga lutaria*, shows a comparatively large pit. The sensory processes are finger-shaped and very numerous.

Text-figure 34.

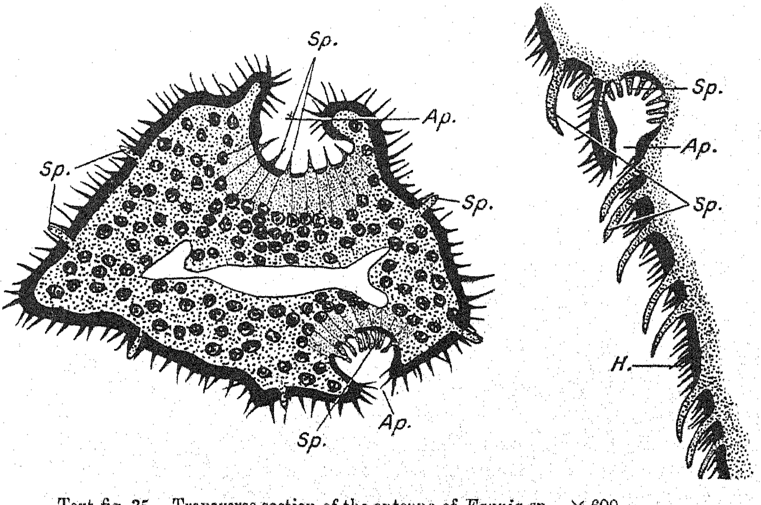


Transverse section through the antenna of *Scatophaga lutaria*. × 600.

ANTHOMYIDÆ (Text-figs. 35–37).

Text-fig. 35 is from a transverse section through the antenna of

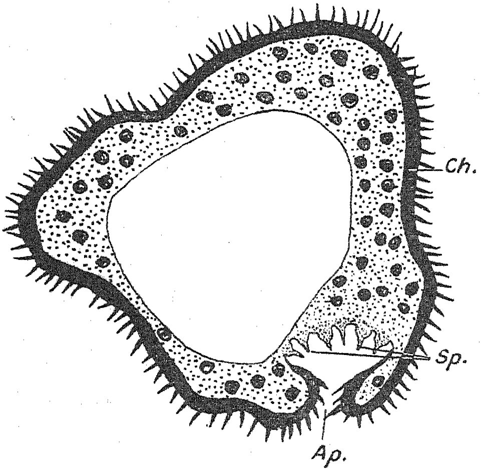
Text-figure 35. Text-figure 36.



Text-fig. 35.—Transverse section of the antenna of *Fannia* sp. × 600.
Text-fig. 36.—Part of a longitudinal section of the antenna of *Fannia* sp. × 600.

Fannia. This shows one large pit and one small one; the sensory processes vary in shape, those in the large pit are pointed while those in the smaller are like a curved finger: this is unusual in the same insect; there are also large thin-walled processes (*Sp.*) arising directly from the general surface. Text-fig. 36 is from a longitudinal section through the antenna of an undetermined species (either *Mydæa* or *Phaonia*). It illustrates a sense-pit and long, rather sickle-shaped processes, very profusely scattered on the general surface. Text-fig. 37 is a transverse section of the antenna of a large Anthomyid, showing a pit and its contained processes.

Text-figure 37.



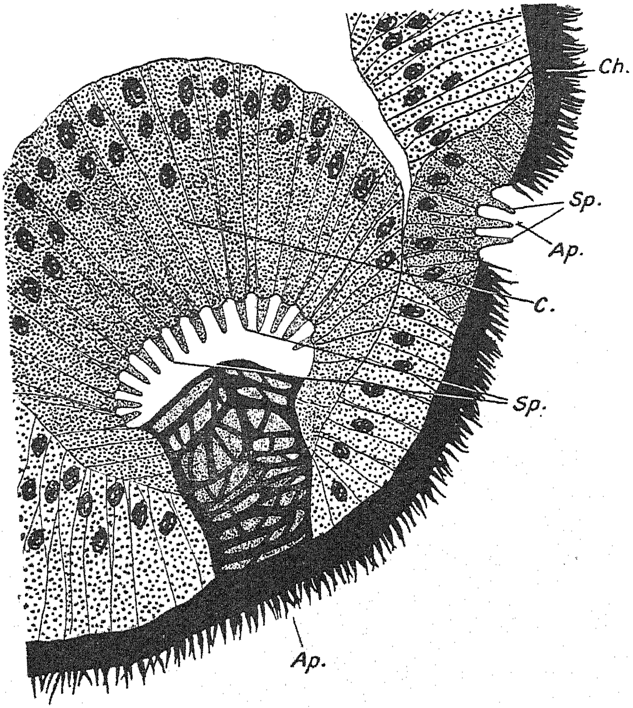
Transverse section of the antenna of an undetermined Anthomyid. × 600.

MUSCIDÆ (Text-figs. 38 & 39 and Pls. II., III., IV. figs. 4–10).

The antennæ in this family possess by far the largest number of pits found in any of the Diptera examined; they do not approach those of the Syrphids in beauty and complication but are rather small and regular. As far as can be ascertained there are no solitary sensory processes on the surface of the chitin, but the sense-pits vary greatly in size, some being very small, with only two or three processes. Text-fig. 38 shows part of a transverse section through the antenna of *Musca domestica.* It illustrates a very beautiful pit, with complex chitinous "basket-work" in the long channel leading inwards from the orifice. The sensory processes are finger-shaped and regular; the whole organ with its large radiating cells gives somewhat the appearance of a fan. A small pit with three sensory processes is shown on the right of the figure.

Pl. II. fig. 4 is a photomicrograph of a transverse section of the antenna of *Calliphora erythrocephala*; this shows the cells running each to its long, straight, sensory process. Pl. II. fig. 6, a transverse section of the antenna of the same insect under a low power, shows one large pit with a number of small ones cut at different levels and mostly opposite to the large pit. Pl. II. fig. 5, a longitudinal section, shows two large pits with their openings and the beginning of a third pit, the large antennal nerve being conspicuous. *C. vomitoria* was also examined and found to be very similar. For a detailed account of this latter insect, see Röhler (9).

Text-figure 38.



Part of a transverse section of the antenna of *Musca domestica*. × 980.

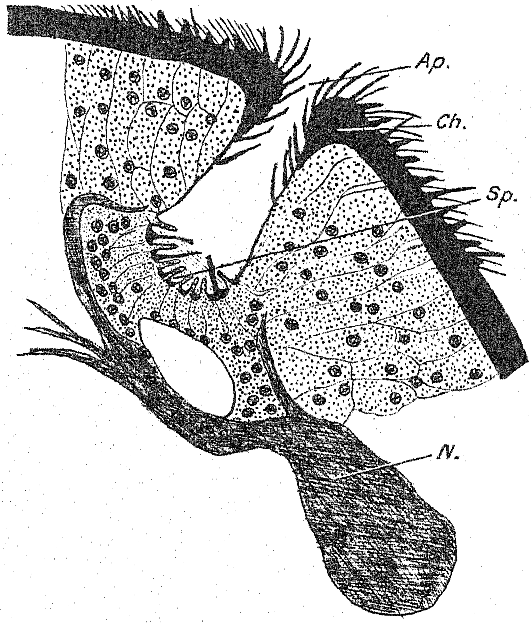
Pl. III. fig. 7 is a photomicrograph of a transverse section taken under a very high power, of a specimen of *Lucilia* having the thoracic chætotaxy of *L. sericata*; it shows the long chitinous hairs at the opening and the short strong sensory processes very wide at the base.

Pl. III. fig. 9, a photomicrograph of the antenna of *Phormia cœrulea* (=*grœnlandia*) cut near the junction of the second and third joints, illustrates the nerve and the variations in shape of the sensory processes. Pl. III. fig. 8, a photomicrograph of a longitudinal section through the antenna of the same insect, shows the position of the sense-pits; they are clustered together at the end of the under surface nearest the head and are eleven in number.

Pl. IV. fig. 10, a photomicrograph of a transverse section of the antenna of *Pollenia rudis*: one pit is visible. The third joint appears to be reinforced in the centre by a strong band of chitin running parallel to the outer walls, which appears black in the photograph.

A form which I have not examined, but in the antennæ of which funnel-like pits have been described (see Deegener (**10**)), is *Muscina stabulans*.

Text-figure 39.



Part of a transverse section of antenna of *Mesembrina meridiana*. × 600.

Text-fig. 39 shows a pit in the antenna of another Muscid, *Mesembrina meridiana* L. (C. G. Lamb det.). It illustrates the long channel running down to the base of the pit (cf. *M. domestica*, text-fig. 38). There are a few short sensory processes, with here and there a chitinous spine.

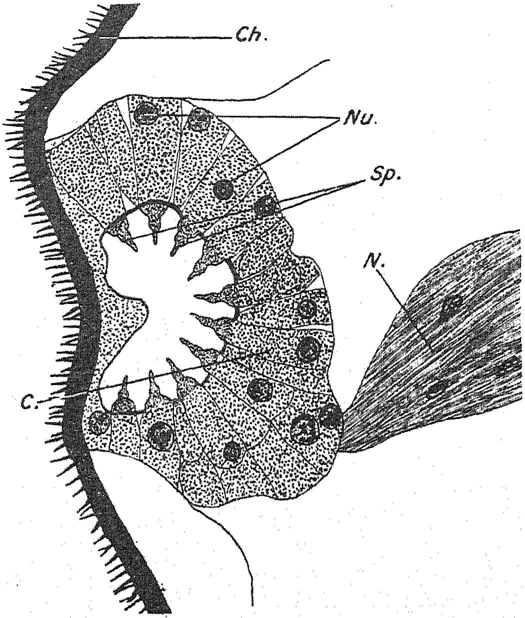
SARCOPHAGIDÆ.

Pl. IV. fig. 11 is a photomicrograph of a transverse section of the antenna of *Sarcophaga carnaria*. Each cell may be seen running to its corresponding sensory process. The processes are broad at the base, changing abruptly to a fine point. The nerve (*N*), which shows black in the photograph, encircles the whole sense-organ.

TACHINIDÆ (Text-figs. 40, 41, and Pl. IV. fig. 12).

Text-fig. 40 shows a transverse section through the antenna of an undetermined species. It illustrates the peculiar shape of the sensory processes and the large nerve running to the sense-pit.

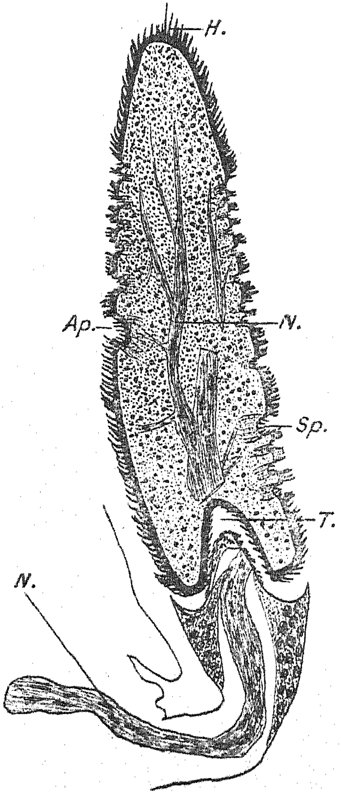
Text-figure 40.



Transverse section of the antenna of an undetermined Tachinid. × 980.

Pl. IV. fig. 12 is a photomicrograph of a transverse section of the antenna of another undetermined species. In this, the sensory processes are long and thin; the nerve is seen enclosing the whole sense-organ. Text-fig. 41, a longitudinal section of the antenna of *Compsilura concinnata* Meig. (=*Phorocera serriventris* Rond.) ♀ (C. J. Wainwright det.), shows the nerve running up from the head and branching in the third joint, and the large number of

Text-figure 41.



Longitudinal section of the antenna of *Compsilura concinnata*. × 128.

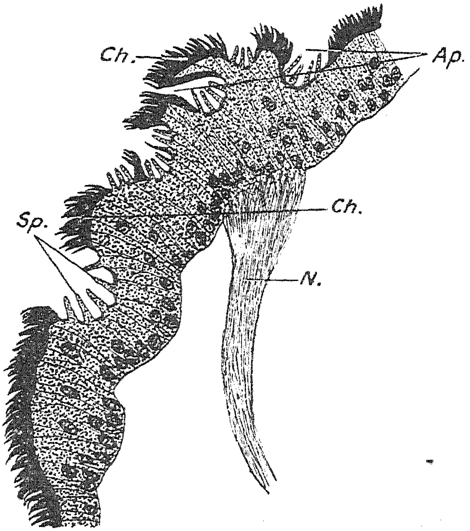
pits of various sizes on each side of the antenna. Mr. Wainwright informs me that this insect is a parasite of many hosts, mostly Lepidopterous, but including also some Sawflies.

Œstridæ (Text-fig. 42).

Gastrophilus equi: the surface of the antenna of this species (text-fig. 42) is beset with small sensory pits with long slender processes, the pits being placed close together. The hairs on the surface are very numerous and give a matted appearance.

Wesché (**5**) pays great attention to this fly and considers it the most highly sensitive of the Diptera, but with this I do not agree (see above).

Text-figure 42.

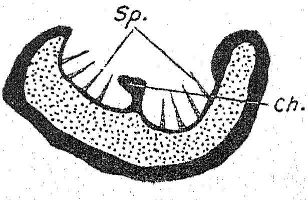


Part of a transverse section of antenna of *Gastrophilus equi.* × 600.

PUPIPARA.

HIPPOBOSCIDÆ (Text-fig. 43). *Ornithomyia avicularia* L. (C. G. Lamb det.): this species has not the true sense-pit, but slight depressions in the surface with a few thin sensory processes.

Text-figure 43.



Transverse section of the antenna of *Ornithomyia avicularia.* × 600.

APPENDIX.

This paper is the outcome of inquiry into the habits of the House-fly which was initiated at the Zoological Gardens in 1915. Miss Lodge's paper on the behaviour of flies has appeared in the 'Bulletin of Entomological Research,' November 1918; this paper is complementary to it, and in trying to arrive at an interpretation of these sense-organs, we have also further unpublished work on the behaviour of flies towards chemicals which aids us in understanding the function of the antennæ. The structure of the sense-organs described above shows a general similarity in fundamental design but marked variation in detail. Speaking broadly the third joint of the antennæ is alone concerned, it is set over its surface with simple sensitive hairs, it contains pits or cavities which have a more complex structure; these pits are as a rule protected or situated on the inner surface of the antenna and the whole joint is set on to the second in a curiously complex fashion. Further, there is in some species an inner chitinous skeleton, which has probably to be considered in conjunction with the elaborate conical structure of the base of the sensory joint.

In considering the function of this antenna, one point suggested itself which we may first dispose of: some flies have the curious habit of hovering, *i. e.* of resting poised in the air, stationary, with a wing velocity adjusted to maintain them so; it seemed possible that the antennæ functioned as a speed-perception organ, relative not to space but to air: that is, the fly was able to feel if it were progressing against the air and when sensation was nil, was stationary. As these organs are less well developed in the Hover-fly section of the Syrphidæ than in the "Bee-fly" section, this is not supported. Another possible view is that they are auditory in function, and some of the more complex pits suggest the auditory organs of Locustidæ; but there is little reason to believe that any flies respond to sound. I think that a great deal of further observation will be required to ascertain if some of the Syrphidæ especially do not have auditory pits, but I think it is not the explanation of the function of the sense-organ generally.

A third point that seems to be clear is that the antennæ and pits are not modified in the sexes: it has long been known that the females of some Fruit-flies secrete essential oils or complex aromatic ketones or aldehydes which are limited within the species and which attract the males in a very wonderful manner: in such cases males must have extreme delicacy of sense perception; but females have equally perfect sense-organs (if these organs are olfactory in function) and they are not secondary sexual characters, as they occur equally well developed in both sexes of each species. Miss Lodge's observations show that flies with the antennæ cut off are unable to retain their balance and readily fall over. I think the structure of these organs shows that the mere cutting of these large nerves must lead to very great nervous disturbance, and there does not seem to be any very good reason to believe that they function in control of the legs.

An enormous number of observations with flies shows that they are extremely sensitive to the presence of certain compounds. If sugar is put out in a room in which there are many flies, the sugar is presently covered with flies; if with the sugar is mixed a chemical substance, it is possible to determine if the flies avoid it, or if it is attractive to the flies. The only compounds to which House-flies are sensitive are the volatile constituents of essential oils, the volatile organic compounds which are soluble in fats, and those compounds which give off ammonia. The compounds are generally those which are fat-solvents, and, apart from the case of *Musca*, the most active are the constituents of essential oils.

The antenna contains (1) a large nerve network, (2) secreting cells and frequently, (3) fat cells. Apparently the hairs over the main surface are filled with secretion, probably of a fatty nature, which picks up essential oils readily. A fly that is a flower-feeder is attracted by the traces of essential oils secreted by the flowers, and directs its course to the flower: arriving there, its large outer surface is probably saturated with the absorption of the perfume; it has still to locate the honey-secreting glands and it is then that the pits come into play. The pits are generally guarded, often on the inner unexposed surface of the antenna, and only very great concentration of the perfume affects them; but they are extra sensitive and aid the fly in locating the source of the perfume in the flower. Flies not only have to find food in flowers, but also to find breeding-places: for some of these, other kinds of odours are certainly the attraction; and some flies have two kinds of pits, one kind of which, I suggest, function for the food, the other function for the breeding-place. *Musca*, for instance, is definitely attracted by ammonia, whether from the manure heap, or from chemical compounds that slowly disengage ammonia: it has two kinds of pits. It is a pure supposition that one of these pits locates one class of compound, another locates another class; but it is borne out by the occurrence of the two kinds in *Eristalis*, which is a flower-feeder and which breeds in decaying organic matter. The explanation that is suggested of these organs is that they are purely olfactory, that the general surface of the antennæ acts for delicate perceptions, that the pits come into play when the concentration of the absorbed liquid has dulled the simple organs on the outer surface, and that the final location of the source of scent is due to the protected pits. Further it is suggested that the presence of two kinds of pits in some species is correlated with the dual perception in the female of food and of breeding-place, in the male, of food and of the female.

There remains the curiously complex cone on which the third joint is set: two explanations are possible: one is that it is a method of rigidly fixing the third joint so that it cannot damage the nerve by bending or twisting motion; the other is that the concentration in the third joint of the antenna of volatile liquids expands it, puts pressure on the cone and gives the fly the impulse to go where the excess of absorbed light will vapourise, so relieving the pressure and also renewing the sensitiveness of the organ. I put this forward as a mere suggestion, but I think that some explanation of this curious structure will be found and that any one who is further investigating the behaviour of flies will find it useful.

There is obviously scope for much detailed observation and for correlated examination of the sense-organs. Mr. Smith's paper offers a fine basis for this work, and if observation of habits can be correlated with investigation of structure, we should get much further in our understanding of the senses and sense-reaction of flies.

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EXPLANATION OF THE PLATES.

Except where otherwise stated, all the sections are through the third joint of the antennæ.

EXPLANATION OF LETTERING:—*Ap.*, aperture of pit; *B.*, base of hair; *C.*, cells; *Ch.*, chitin: *H.*, hairs; *N.*, nerve; *Nu.*, nuclei; *Sp.*, sensory process or sensillus; *T.*, top of second joint of antennæ.

PLATE I.

Fig. 1. Part of a transverse section of the antenna of *Eristalis tenax*. × 600.
2. Transverse section of the antenna of *Eristalis tenax*, showing the "simple" pit. × 128.
3. Transverse section of antenna of *Xylota sylvarum*. × 128.

PLATE II.

Fig. 4. Transverse section of the antenna of *Calliphora erythrocephala*. × 600.
5. Longitudinal section of the antenna of *C. erythrocephala*. × 600.
6. Transverse section of the antenna of the same insect. × 128.

PLATE III.

Fig. 7. Transverse section of the antenna of *Lucilia sericata*. × 980.
8. Longitudinal section of the antenna of the same insect. × 600.
9. Transverse section of the antenna of *Phormida cœrulea*. × 600.

PLATE IV.

Fig. 10. Transverse section of the antenna of *Pollenia rudis*. × 600.
11. Transverse section of the antenna of *Sarcophaga carnaria*. × 600.
12. Transverse section of the antenna of an undetermined Tachinid sp. × 600.

7. The Progressive Reduction of the Jugal in the Mammalia. By LANCELOT T. HOGBEN, B.A., B.Sc.*

[Received February 27, 1919 ; Read April 8, 1919.]

Although the character of the zygomatic arch is at once a most diagnostic feature of the Mammalia as a class, and one which undergoes profound modification in the individual orders and families, no adequate general account of it has been given since Slade † contributed to our knowledge of the features it exhibits in response to the functions it is called upon to perform. Significant as it is, however, to appreciate the manner in which the development of the zygomatic arch depends on the energy and character of the masticatory process, such treatment does not exhaust the interest of its structure. Cases occur abundantly where, though otherwise similar in curvature, resistance, and functional significance, it is fundamentally dissimilar in the part played by its component elements ; and a careful study indicates a tendency for the suppression of the jugal element independently manifested along totally divergent lines of mammalian descent. Moreover, while the manner in which the zygomatic arch is adapted to the requirements of different types of mammalian organization leads to considerable diversity in its structure, there are some striking particulars of resemblance where its physiological importance may be totally different ; and the student of morphology cannot fail to give consideration to any details of contrast and comparison which do not seem to be called into being by the conditions of environment and in consequence capable of being attributed to convergent evolution. Certain points which remain therefore to be set forth or emphasized seem to justify a brief survey of the role played by the malar among the mammalia, though it may necessitate repeating matter already published.

In no group of Placentals except the Carnivora does the zygomatic arch show the same uniformity of structure as in the Marsupials, and when the varied types of dentition and diet exemplified by the latter group are taken into account, this fact should merit serious attention in discussing the possible diphyletic origin of the group. It may at least be inferred that the type of structure which characterizes the Marsupials approximates closely to the ancestral condition. In all living Metatheria the jugal plays a conspicuous part in its formation—even in the singular genus *Notoryctes*. It is a robust structure usually curving outwards conspicuously. The relations of the jugal are in general the same : it extends from the lacrymal antero-dorsally at the border of the orbit to the glenoid postero-ventrally. The squamosal, however, always occupies a large proportion of the dorsal side of the arch; and it is perhaps not strictly accurate to state* that the jugal always actually participates in the formation of the glenoid cavity, because though the latter may be compact, as in *Phascolarctus*, its limits are not always clearly defined. Not infrequently it is a large smooth area, tapering off imperceptibly to the flattened ventral rim of the arch, and when the condyle of the mandible is small only a portion of this surface is strictly articular. It is certain for example that the head of the mandible in its normal rotation does not come into contact with the jugal in the Rat Kangaroo, *Hypsiprymnus rufescens*. The postorbital process of the zygomatic arch is but slightly indicated, indifferently by the squamosal or jugal or both among closely allied genera, and the same variability in the relation of the different elements of the zygomatic arch to the eye-socket is encountered among the various orders of the Placentals. Widely as the structure of the zygomatic arch differs among the Placentalia, the part played by the jugal in its composition varies more remarkably. In a large number of genera that occupy a somewhat isolated position, and appear to have diverged from the main lines of mammalian phylogeny at an early date, and also in some cases in the less specialized members of the larger groups, the jugal displays what may be regarded as the ancestral condition, extending from the lacrymal antero-dorsally to the glenoid postero-ventrally. But more generally it becomes displaced by the encroachment of the squamosal and maxilla, its reduction being sometimes accompanied by a strengthening of the zygomatic arch or in others by a weakening, and frequently without any evident modification either of its contour or its rigidity.

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* Communicated by Mr. H. W. UNTHANK, B.A., B.Sc., F.Z.S.

† Slade, D. D. "The significance of the Jugal Arch." Pr. Amer. Phil. Soc. xxxiv., 1895.—*Cf.* also Hallman, E., "Die Vergl. Osteol. die Schlafenbeins."

In the Rodentia the zygomatic arch is always comparatively well developed; and no student of this group can fail to be impressed by the highly characteristic modifications it undergoes among the various families. Brandt †, following Waterhouse, paid particular attention to the character of the zygomatic arch in his classification of the Rodents; and it may be said that his system would have approximated more nearly to those of subsequent investigators ‡, if he had studied the relation of its constituent elements in more detail. Thus the Bathyergidæ placed by him with the Myomorpha, the Anomaluridæ and Haplodontidæ in the Sciuromorpha, should be separated from those groups on account of the relations of the jugal bone if for no other reason.

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* Weber, Max: "es erstreckt sich bis zur Fossa glenoidea und bildet deren Aussenfläche." Einführung in die Anatomie systematik der recenten und fossilen Mammalia.

† Brandt, J. F. "Untersuchungen über die craniologischen Entwickelungsstufen und die davon herzuleiteten Verwandtschaften und Classificationen der Nager der Jetztzeit, mit besonderer Beziehung auf die Gattung Castor." Mém. Ac. Sci. St. Pétersbourg, 1855.

‡ Winge, H. "Jordfundne og nulevende Gnavere." E Museo Lundi, 1888.
Tullberg, T. "Ueber das System der Nagethiere." Upsala, 1899.

In the Sciuridæ and Castoridæ the jugal is least reduced, forming almost the entire arch and extending from the lacrymal antero-dorsally to participate in the formation of the glenoid postero-ventrally. In most of the remaining families the jugal is invaded by the maxilla from before and the squamosal from behind. In a number of families the jugal still meets the lacrymal: such are the Pedetidæ and Anomaluridæ, Dipodidæ, Bathyergidæ, and, in marked contrast with the other Hystricomorphine families, the Chinchillidæ. In the Hystricidæ, Erethizontidæ, and the Caviidæ the zygomatic process of the maxilla encroaches further and occupies a large portion of the arch excluding the junction of the jugal with the lacrymal; but the jugal nevertheless takes part in the formation of the glenoid cavity, although in the larger Cavies it is covered over on the external side of the arch by a superficial extension downwards of the squamosal. This is conspicuously the case in *Hydrochœrus*, in which genus the jugal appears on the outer side to be reduced to a narrow vertical wedge of bone between the zygomatic processes of the maxilla and squamosal, albeit in curvature and general characteristics the zygomatic arch conforms in a striking manner to the hystricine type. In fact, *Hydrochœrus*, which in several respects apart from its great size appears to be one of the most highly specialized members not only of the Caviidæ but of the Rodents, illustrates forcibly the general tendency among the Mammalia for the displacement of the jugal without apparent reference to function at all. The most extreme reduction of the jugal is met with in the Murine forms, where the whole arch is very slender and largely composed of the maxillary zygomatic process which approximates closely to that of the squamosal. In the Duplicidentata, on the other hand, the jugal forms almost the entire arch extending behind but not actually uniting with the glenoid. There is rarely any marked post-orbital process in the zygomatic arch in Rodents.

Among the S. American Edentates the zygomatic arch is complete only in the Dasypodidæ, where considerable differences are exhibited even among members of the same genus. In *Dasypus sexcinctus*, *Chlamydophorus*, and in *Priodontes gigas* the jugal curves downwards and articulates with the squamosal by a horizontal fissure; and in the first two genera there is a slight indication of the downwardly directed process so characteristic of the Sloths and Glyptodontidæ. In *Tatusia hybrida* the jugal also curves downwards, but articulates with the squamosal vertically. In *Tatusia novemcincta* the arch is represented by a broad straight bar mainly composed of the jugal element. In the remaining recent families the jugal fails to meet the zygomatic process of the squamosal, though in the Bradypodidæ it is a large bone characterized by a ventral prolongation. In the Myrmecophagidæ the jugal is slender and often styliform, while the zygomatic process of the squamosal is represented by a blunt projection except in *Myrmecophaga tamandua*, where it is drawn out into a tapering process that almost meets the jugal. There is evidently within the Xenarthra a tendency for the reduction of the jugal along several genetic lines; yet despite the variety of structure displayed by the zygomatic arch among Edentata vera, there is one feature common to all the families of which it is composed: the jugal, however much reduced from behind, not only meets the lacrymal but extends well in front of the orbit though less conspicuously than in the Ungulates. Insignificant as this might at first appear, it is striking in view of the extraordinary diversity exhibited in the habit, diet, general organization, and in other characters of the zygomatic arch itself; and there is every reason to regard it as a common ancestral peculiarity.

Whether this conclusion is correct or not, the Xenarthra are in this respect sharply differentiated from the two spurious groups of Edentata, Pholidota and Tubulidentata. In the Manidæ the zygomatic arch, being incomplete, superficially resembles that of the Myrmecophagidæ; but there is a zygomatic process to the maxilla and the jugal is absent. If it were present, it would occupy the middle rather than the anterior portion of the arch as in the Myrmecophagidæ. In *Orycteropus* the zygomatic arch is complete; and the maxilla forms at least half of it, reducing the jugal to a slender rod between it and the well-developed zygomatic process of the squamosal. It is interesting in relation to Elliot Smith's view * that the Tubulidentata show affinity with the Protungulate stock, to note that in all modern Ungulates and *Hyrax* the jugal suffers no displacement on account of the maxilla.

Among the Carnivora there is striking uniformity in the character of the zygomatic arch which, as Slade observes, maintains in all outstanding particulars the same features as those exhibited by the Creodonta. It is a robust structure curving upwards generally from behind. The jugal forms a large part of the arch and may extend back to the glenoid as in *Lutra*: in front, it never extends beyond the anterior boundary of the orbit; but it articulates with the lacrymal universally in the Fissipedia. On the internal surface of the arch the zygomatic processes of the squamosal and jugal sometimes meet. There is a postorbital process usually on the jugal, and sometimes on the squamosal. The Pinnipedia display the same general characteristics except that the lacrymal is absent. Significantly enough, the jugal extends back to the rim of the glenoid in the two families least specialized to aquatic life—the Otariidæ and Trichechidæ; whereas in the true Seals (Phocidæ) the extent of the jugal both at its anterior and posterior extremities is in a marked manner more restricted by the growth of the maxilla and squamosal, though it cannot truly be said that the zygomatic arch is essentially different in other respects.

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* Smith, G. Elliot. "The Brain in the Edentata." Trans. Linn. Soc. London, vii., 1899.—*Cf.* also Wortman. "The Ganodonta and their relations to the Edentata." Bull. Amer. Mus. Nat. Hist. ix., 1897.

The jugal bone in the Ungulates articulates with the lacrymal, extending beyond the anterior border of the orbit, as in the Xenarthra, and constituting an appreciable part of the facial region of the skull. The zygomatic arch is universally complete, and at its posterior end is nearly always flattened. Among the Tapiridæ and Rhinocerotidæ the jugal is least reduced in the Perissodactyle forms, where the orbit is not enclosed. In the Equidæ the posterior extremity of the jugal does not extend vertically behind the orbital ring which is completed by the junction of the frontal with the squamosal. In the Pecora, Tragulina, and Tylopoda the zygomatic arch is so similar as to separate these three groups widely from the Suina. The orbit is enclosed by the union of the jugal with the frontal, and the former does not extend far behind it postero-ventrally. But in the less specialized Suina, where there is no separation of the orbit from the temporal fossa, the jugal may extend back to the glenoid cavity as in *Sus* and *Dicotyles*. Here the same tendency for the displacement of the jugal by the zygomatic process of the squamosal manifests itself, as has been referred to already in Pinnipedia. In *Hippopotamus* alone does the enclosure of the eye-socket occur—and not invariably throughout the genus; but the structure of the orbital ring when complete differs in this case from that of the higher Artiodactyla in that the jugal and the frontal meet one another on the anterior rim of the orbit internal to the lacrymal bone.

The jugal is not prolonged into the facial region beyond the lacrymal in the Hyracoidea, the condition of the zygomatic arch being similar to that which obtains in the Marsupials and some Rodents. The jugal enters largely into the formation of the glenoid cavity: in no mammals do the maxilla and squamosal play less part in the formation of the arch; and if the modern Hyracoidea provide any indication of the type of zygomatic arch prevalent in the protungulate stock, although it may be admitted that the extension of the jugal into the facial region is a secondary modification, the considerations stated with regard to the reduction of the jugal both in the Perissodactyles and Artiodactyles are nevertheless greatly reinforced.

The progressive reduction of the jugal is clearly illustrated in Andrews's work on the ancestry of Elephants. In the modern forms the maxilla is extended backwards in a stout zygomatic process excluding the union of the jugal with the lacrymal; and the squamosal approaches it upon the dorsal side of the arch. The jugal, which is reduced to a narrow segment interposed between them, sends back a slender limb postero-ventrally which takes part in the formation of the glenoid. The participation of the jugal in the jaw articulation does not appear to be a secondary condition, for, as Dr. Andrews* observes, in *Mœritherium* "the jugal is large and forms the greater part of the zygomatic arch. Posteriorly it runs back beneath the zygomatic process as far as the glenoid cavity in the formation of which it takes a small share."

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* Andrews, C. W. Tageblatt des V. Int. Zool. Cong. Berlin, No. 6. Phil. Trans. vol. 196.

There is little to add to accounts previously given relating to the jugal arch in the Sirenia and Cetacea. In the Sirenia the arch is massive, particularly in *Manatus*, and the jugal curves deeply downwards in *Halicore*. The malar suffers little displacement on account of the maxilla and it extends postero-ventrally near the glenoid. In *Manatus* the jugal almost meets the frontal behind the orbit. In the Cetacea the jugal joins the lacrymal when the latter is present; and the separation of the orbit from the temporal fossa is achieved as in the Equidæ by the union of the squamosal with the frontal.

Winge*, in his recent revision of the Insectivora, lays stress on the early separation of the Dermoptera, Cladobatidæ, and Macroscelidæ from the other families of the order; but again overlooks the morphological value of the zygomatic arch. For nothing more emphatically distinguishes the Tupaiidæ (Cladobatidæ, Winge) and Macroscelidæ than the relations of the jugal. In all the remaining families it is greatly reduced, so that the arch is frequently incomplete owing to its total suppression as in the Soricidæ, Centetidæ, Solenodontidæ, and Potamogalidæ. In the Erinaceidæ, Talpidæ, and Chrysochloridæ, it is present as a slender element inserted in the middle of the arch between the zygomatic processes of the maxilla and squamosal; never does it join with the lacrymal. In marked contrast, on the other hand, the relations of the jugal in the Tupaiidæ and the Macroscelidæ are essentially similar to the condition characteristic of the Metatheria, *Hyrax*, and certain Rodents: that is, it extends back to the glenoid ventrally and reaches forward to meet the lacrymal on the anterior border of the orbit. In the aberrant genus *Galeopithecus* the jugal is even more powerful and contributes a large share in the formation of the glenoid cavity.

In the Chiroptera the zygomatic arch is complete; but the role of the jugal is greatly restricted, as in the Erinaceidæ. The maxilla displaces the jugal, not as is usually the case on the ventral side, but dorsally; and sometimes comes into contact with the squamosal element on the upper border of the arch.

The enclosure of the eye-socket, which has been independently effected in certain of the more specialized members of other orders, has become a fixed character in the Primates through the union of the postorbital process of the jugal with the frontal, so that the former has acquired a new role. The jugal does not usually extend far behind its junction with the frontal in the Lemurs and in the Anthropoidea; but in certain genera of the Prosimiæ it may extend back to the glenoid, as e.g., *Chiromys*, *Indris*, and *Tarsius*. A more rigid distinction—not previously mentioned—between the Lemuroidea and the higher Primates than the complete enclosure of the orbit by the ingrowth of the jugal to meet the alisphenoid, is to be found in the fact that the jugal articulates with the lacrymal in the former but not in the latter group. It is frequently stated, even by such authorities as Weber*, that the Catarrhina are distinguishable from the Platyrrhina by the junction of the jugal with the parietal in the last named; but this is not by any means a universal rule. In *Mycetes* the jugal does not meet the parietal; and a specimen of *Ateles ater* in the Birkbeck College collection shows the jugal joining the parietal on one side of the skull but not on the other.

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* Winge. "Udsigt over Insektaedernes indbyrdes Slaegskab." Vidensk. Meddel. f. Dansk Naturhist. Forening Kjöbenhavn, 68. 1917.

A comparison of the skull in the Anthropoidea with that of forms like *Chiromys* and *Indris* suggests that even in the Primates, in which the role of the jugal has become relatively more important on account of its inclusion in the orbit, it has not escaped the general tendency towards reduction by the invasion of the squamosal or maxilla or both apparently developed independently along the various lines of mammalian phylogeny, as indicated in the previous survey. It is without doubt true that so far as the curvature and strength of the zygomatic arch is concerned, its development, as Slade observes, "depends upon the energy and character of the masticatory process." Nevertheless, if the problem is approached in the light of modern evolutionary theory with the mind less taxed with the necessity of discovering utility in every structure, it is difficult to reveal any general teleological significance in the part individually contributed by the various elements of which it is composed. Seeing that in a diversity of isolated genera among the Placentals exhibiting every possible variety of diet and habit, and also in some of the less specialized representatives of the larger groups themselves, the jugal displays essentially the same relations as in the Metatheria, namely, extending postero-ventrally from the glenoid to the lacrymal antero-dorsally, it is hardly possible to agree with Weber that the jugal was small in the earliest Mammalia (*op. cit.*) as in the Insectivora of to-day: on the contrary, there can be little doubt that this represents the ancestral condition retained by the class till a date later than that at which the modern lines of Mammalian descent had become differentiated. In some cases the jugal has become effectively eliminated although the arch is complete and even robust, as in the Monotremes† where the malar is vestigial or absent, at least as a separate ossification. The reason for this progressive reduction of the jugal quite irrespective of the form and function of the arch, as is most emphatically demonstrated by a comparison, for instance, of the skulls of *Erethizon* and *Hydrochœrus*, remains obscure. Nevertheless, the manner in which it is effected among the different orders of Mammalia is so characteristic and, in a sense, conservative that similarity in the morphological relations of the jugal in Mammals that exhibit different habits of nutrition should prove of greater service for the elucidation of phylogenetic problems and taxonomical difficulties than has hitherto been recognized.

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* Weber, Max. Einführung in die Anatomie und Systematik der recenten und fossilen Mammalia. Jena, 1904.

† *Vide* Sixta: "Untersuchung über den Bau des Schaedels von Monotremen und Reptilien," Zeitschr. f. Morph. und Anthropol. ii., 1900.

A similar shrinking of the postorbital due to genetic factors at present unknown would appear to account for the disappearance of that bone in the Theromorpha. For clearly the suppression of the postorbital cannot be assigned to any teleological reason, since, as has been indicated above, the separation of the orbit from the temporal fossa has been reacquired—presumably to meet an evident physiological need—by entirely different devices in several orders of modern Mammalia independently.

8. Descriptions of two new Lizards and a new Frog from the Andes of Colombia. By G. A. Boulenger, F.R.S., F.Z.S.

[Received March 7, 1919: Read April 8, 1919.]

(Published by permission of the Trustees of the British Museum.)

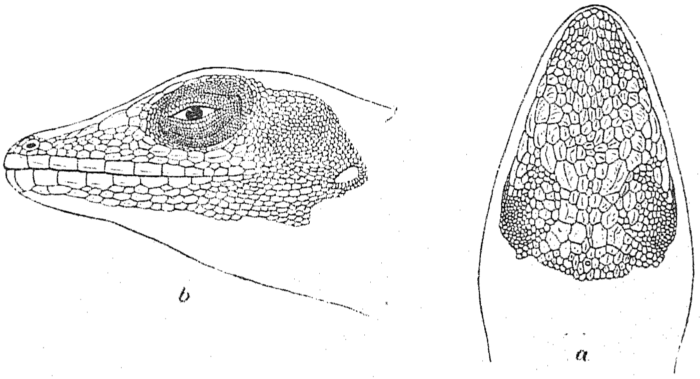
(Text-figures 4 & 5.)

A collection of Reptiles and Batrachians from Bogotá and neighbourhood, sent to me for identification by Bro. Apollinaris-Maria, of the Instituto de la Salle, Bogotá, contained examples of three new species, of which descriptions are here given. The types are preserved in the British Museum.

Anolis apollinaris, sp. n.

Head nearly once and a half as long as broad, scarcely longer than the tibia; forehead concave; no frontal ridges; upper head-scales rather small, strongly keeled; supraorbitals enlarged, separated by two or three series of scales; occipital not enlarged; canthus rostralis short and strong; canthal scales four; loreal rows five; 9 or 10 upper and as many lower labials; ear-opening oval, half the diameter of the eye-opening. Body compressed; dorsal and lateral scales very small, granular, strongly keeled, larger on the vertebral region; ventral scales feebly keeled, larger than largest dorsals. The adpressed hind limb reaches the eye; digital expansions strong; 25 lamellæ under phalanges II and III of the fourth toe. Tail cylindrical, covered with small strongly keeled scales, its length more than twice that of head

Text-figure 4.



Anolis apollinaris.

and body. Dark olive above and on the sides, with a fine blackish network; head and a vertebral band pale, the latter with narrow transverse processes; small round light spots on the sides and tail; fore-arm, tibia, and lower parts pale green.

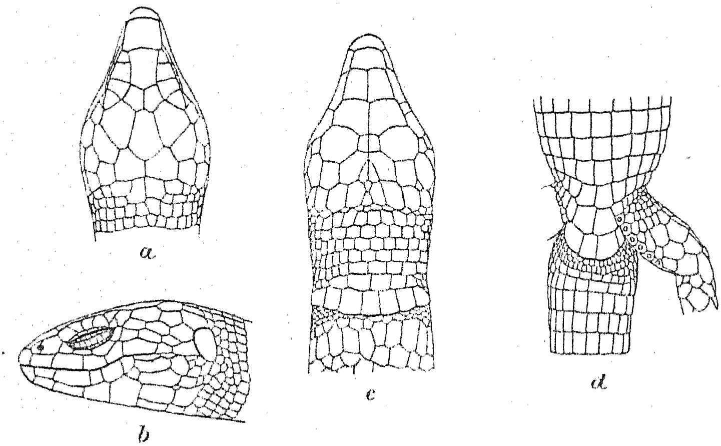
Total length	396 mm.
Head	26
Width of head	17
Body	80
Fore limb	46
Hind limb	81
Tibia	25
Tail	290

A single female specimen from near Bogotá.

PROCTOPORUS BOGOTENSIS, sp. n.

Head rather large, with obtusely pointed snout and swollen temples; limbs moderately developed, meeting when pressed against the body. Frontonasal as long as broad, as long as and broader than the frontal, which is twice as long as the suture between the frontoparietals and a little shorter than the interparietal; latter widening posteriorly, nearly the same length as the parietals, which form an oblique suture with the large upper temporals; a pair of large occipitals; four supraoculars, three in contact with the frontal; nasal divided; no loreal; a series of suborbitals; three upper labials to below eye; one anterior and three pairs of large chin-shields, the first two pairs forming a suture;

Text-figure 5.



Proctoporus bogotensis.

9 rows of scales between the latter and the collar; 8 collar-shields. Dorsal scales twice to twice and a half as long as broad, tricarinate, forming uninterrupted series across the back; 31 scales from occiput to sacrum inclusively. Ventral scales, except the two outer rows on each side, as long as broad or a little longer than broad, in 10 longitudinal and 23 transverse series. 32 scales round the middle of the body. 5 large præanal shields ($\frac{2}{3}$). 6 femoral pores on each side. Tail thick, scales as on the body, but dorsals shorter and ventrals narrower. Brown above, with five black longitudinal streaks beginning on the head; throat white, spotted with black; belly black, with small white spots.

Total length (tail reproduced)	115 mm.
Head	13
Width of head	9
From end of snout to fore limb	20
” ” vent	60
Fore limb	16
Hind limb	19

A single male specimen from Bogotá.

HYLIXALUS GRANULIVENTRIS, sp. n.

Tongue distinctly nicked behind. Head as long as broad; snout rounded, projecting beyond the mouth; canthus rostralis distinct; loreal region feebly oblique, feebly concave; interorbital region as broad as the upper eyelid; tympanum distinct, half the diameter of the eye. Fingers moderate, first and second equal, the tips dilated into small discs; subarticular tubercles well developed. Toes half-webbed, the web extending as a fringe to the discs, which are larger than those of the fingers; subarticular tubercles feebly prominent; an oblique fold on the distal half of the tarsus, extending along the inner side of the first toe; an oval inner and a round outer metatarsal tubercle. The tibio-tarsal articulation reaches the anterior border of the eye; tibia a little less than half the length of head and body. Upper parts smooth, with a few small, feebly prominent warts on the head and back; throat and belly strongly granulate. Upper parts and throat blackish; belly and lower surface of limbs white. Male with an internal vocal sac.

From snout to vent 22 millim.

A single male specimen from Bogotá.

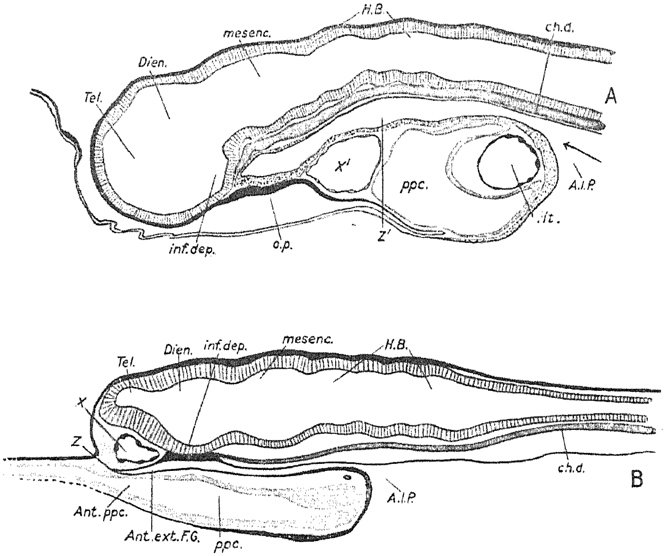


FIG. 7.

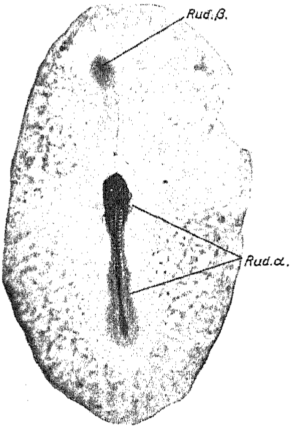


FIG. 1.

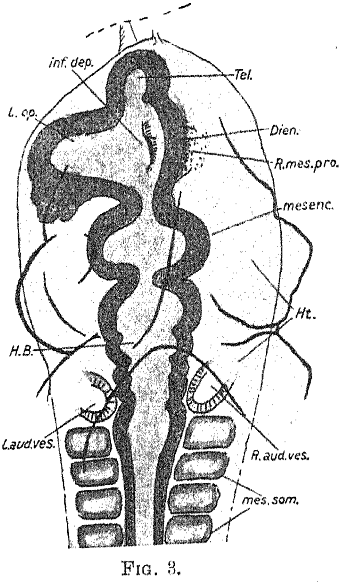


FIG. 3.

A DOUBLE CHICK EMBRYO.

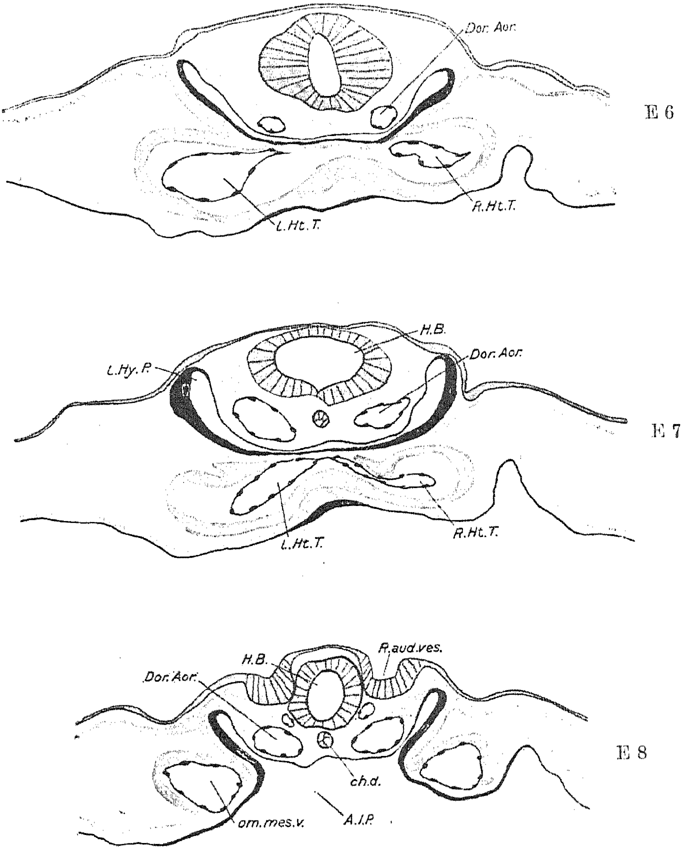


FIG. 5.

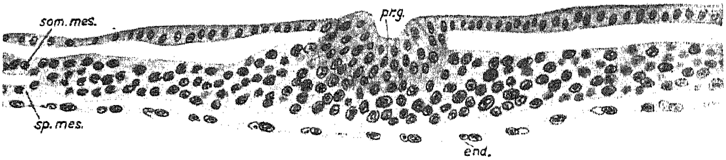


FIG. 2.

A DOUBLE CHICK EMBRYO.

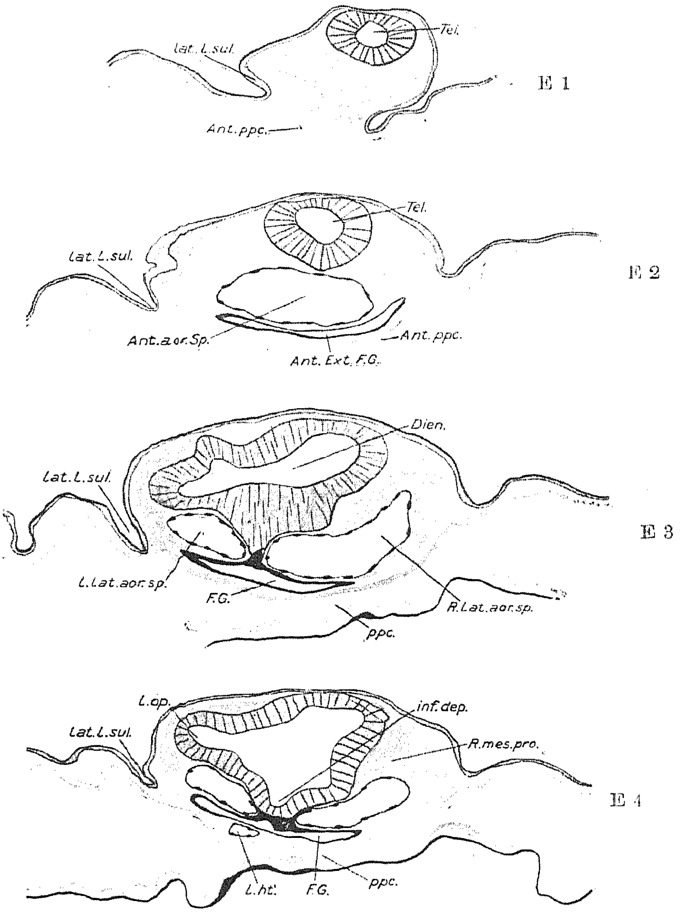


FIG. 4.

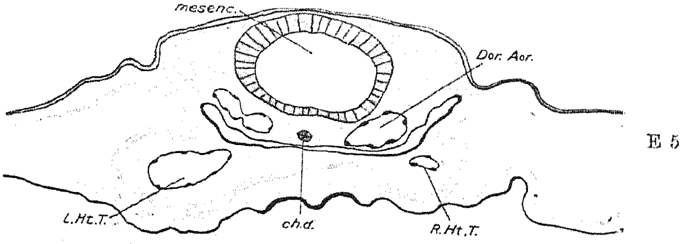


FIG. 5.

A DOUBLE CHICK EMBRYO.

9. A Unique Case of Asymmetrical Duplicity (*Duplicitas asymmetros*) in the Chick. By NOEL TAYLER, B.Sc. (Lond.)*. (From the Zoological Department, University of London, University College.)

[Received April 8, 1918: Read May 13, 1919.]

(Plates I.–III.† and Text-figures 1 & 2.)

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I. INTRODUCTORY NOTE.

The following paper consists of two main parts, firstly the description of the blastoderm, and secondly a discussion as to its mode of origin and development. Its bearing on teratological problems is also very briefly considered.

Hitherto little attention has been paid to the abnormal products of morphogenesis, largely, no doubt, owing to the scantiness of our knowledge of the causal factors of development; nevertheless, it would seem that, in view of the important bearing that the abnormal must have in the interpretation of the normal, it is deserving of more attention than it has hitherto received. It was thought, therefore, that it might be quite worth while to take such a case as the present and subject it to a somewhat detailed consideration from two aspects. Firstly, with respect to the morphogenetic problems which it might itself present, considered in relation to what is known of the factors of normal development, and secondly with respect to its own bearing on our knowledge of the latter and on some of the general problems of teratology.

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* Communicated by Prof. J. P. HILL, F.R.S., F.Z.S.

† For explanation of the Plates see p. 109.

I have been unable to find any described instance of any blastoderm closely resembling it, and it appears of some interest in connection with several morphogenetic questions, in particular with the problem of the factors concerned in the early development of the anterior portion of the embryo and also with that of the localisation of the prospective embryo upon the blastoderm.

It also has a bearing on at least two teratological problems, the mode of origin of double monstrosity, and the nature of that particular and little studied type of duplicity in which the two components are unequally developed—the Duplicitas asymmetros of Schwalbe.

II. Descriptive.

The Morphology of Blastoderm E, and the embryonal formations.

A. *General appearance of the Blastoderm and orientation.*

The blastoderm described in the following pages was very kindly placed at my disposal some time ago by Prof. J. P. Hill, F.R.S., to whom I wish to express my thanks for his assistance in reading and criticising this paper. When the blastoderm came into my hands it was in an unstained condition, and after being stained with borax carmine and examined as a whole mount it was cut into serial sections for more detailed study.

Unfortunately I am unable to state the time of incubation, of which there is no record.

In the first place I shall give a brief description of the gross morphology of the blastoderm, and then after reference to the structure of the lesser rudiment and to the relations of the two embryonal centres as determined from a study of the sections, shall proceed to a description of the morphology of the greater embryonal rudiment.

Pl. I. fig. 1 is a reproduction of a photograph of the blastoderm, which it will be seen is oval in shape, 12 mm. in length by 7 mm. in breadth.

Situated in the median longitudinal axis of the blastoderm is the more completely developed formation, which will henceforth be designated as Rudiment α or alternatively the greater or major embryonal formation. It was found to possess 17 pairs of mesoblastic somites, and is normally developed as regards its posterior region.

In Pl. I. fig. 3 the abnormality of the anterior region, which is chiefly evident in the position of the anterior intestinal portal and in the condition of the Fore-Brain, is apparent.

In the anterior prolongation of the long axis of Rudiment α and situated rather over 2 mm. from the anterior limit of its Fore-Brain, is the lesser or minor embryonal formation which will be designated in the sequel as Rudiment β (see Pl. I. fig. 1).

This lesser embryonal formation may be concisely described as a primitive-streak-like rudiment, and its longitudinal axis as defined by its "primitive groove" is, with reference to the continuation of the longitudinal axis of Rudiment α, bent to the left at an angle of about 30°.

Between the two embryonal formations there runs what appears in the whole mount as a more darkly staining strand (Pl. I. fig. 1) which will be more minutely described in the sequel.

The longitudinal axis of Rudiment α will be used as a basis for the orientation of the whole blastoderm; thus, when we speak of the posterior end of the Rudiment β we imply that portion of it situated proximally or nearest to Rudiment α.

B. *Detailed description of the relations of the two Embryonal Formations and the structure of the lesser* (Rudiment β).

Reference may now be made to the structure of the lesser rudiment, which is more properly described as "primitive streak-like" than as a primitive streak.

It will be seen from the figure that it consists of two main parts, a rather diffuse and somewhat darkly staining oval area, and the more deeply staining primitive streak proper (Pl. I. fig. 1, Rud. β) with its more translucent primitive groove.

The dimensions of the dark oval area, which the sections show to consist of thickened mesoblast, are about $78\mu \times 64\mu$, while the length of the "primitive groove" is about 28μ.

Pl. II. fig. 2 represents a section of Rudiment β in the region of the primitive groove. It will be seen that it is quite comparable to the sections of a rather advanced primitive streak.

The three primary germ-layers are well defined and separate except in the region of the "primitive groove" (*Pr.g.*) where the ectoderm and mesoderm are in continuity. One receives the impression from these sections that there is, in this region, a well marked proliferation of the median ectoderm as in the normal primitive streak.

Peripherally the mesoderm splits into somatic and splanchnic layers on either side (Pl. II. fig. 2, *Som.mes.*, *Sp.mes.*), the cœlom thus formed being portions of the parietal cavity.

The median unsplit mesoderm extends back from the region of the "primitive groove" for some distance as will be seen from Pl. I. fig. 1; in section, it is seen to become free from the superimposed ectoderm, and this fact suggests the question as to whether or not we might be justified in regarding it as of the nature of a head-process. If we are so justified, it would become necessary to regard Rudiment β as orientated in the reversed direction to Rudiment α, *i. e.*, the two embryonal formations would be placed head to head (→ ←) and not in the same direction (→ →).

It may be noted that cases have been recorded of two opposing embryonal formations placed upon a single germinal area. Such a case was described by Mitrophanow (8), in which the two embryonal rudiments were represented by two primitive streaks about equally developed; while other and older stages have been recorded by Kaestner and others (6, 7).

Under the circumstances however, the question does not seem one of great importance, and it seems better to refrain from any definite decision as to the orientation of Rudiment β.

No structure seems to be present which can undoubtedly be regarded as a "primitive knot."

We may now turn to the morphological relationships of the two embryonal formations. These two structures occurring in a single blastoderm, the three primary germ-layers of each and those of the extra embryonal portion of the blastoderm, are of course continuous each with each. It may also be noticed that, whilst the sinus terminalis is perfectly regular in outline, the area pellucida shows signs of division into two regions of greater transparency (see Pl. I. fig. 1) in relation to the two embryonal formations, since the blood islands of the vascular area are concentrated somewhat in the regions posteriorly and postero-laterally to Rudiment β. It is of more importance, however, to find that there is what may be described as a definitely differentiated morphological connection between the two embryonal formations, viz., the rather darkly staining and irregular strand which in the photograph of the whole mount (Pl. I. fig. 1) appears to run in the long axis of the blastoderm between the two embryonal rudiments. In the sections this is found to consist of a narrow and somewhat irregular band of unsplit mesoderm, thicker and broader in the region of the Rudiment β and becoming more tenuous and irregular as it comes into proximity to Rudiment α.

Its somewhat irregular and broken appearance in the whole mount is seen from the sections to result from the presence of vessel-like lacunæ in its substance, spaces, however, which are devoid of blood corpuscles.

On either side of this median strand the mesoderm splits into somatic and splanchnic layers, and it would seem that the extra-embryonal cœlom situated laterally to Rudiment β and to the mesodermal strand is continuous with the parietal cœlom of Rudiment α.

C. *The Morphology of the greater Embryonal Formation* (Rudiment α).

Proceeding to a consideration of the structure of Rudiment α, the morphology of the posterior region may be briefly dismissed as it is that of a normal embryo of 17 somites. Pl. I. fig. 3 and text-fig. 1 represent a semi-diagrammatic figure of the morphology of the anterior region, while transverse sections through the more important regions are shown in Plates II. and III. figs. 4 & 5. The positions of these transverse sections are indicated in text-fig. 1.

In section D, p. 91, is given a concise summary of the more important morphological abnormalities which occur in Rudiment α, and this is subdivided into four categories, viz., those affecting the general proportions of head, the nervous system, the gut, the vascular system, and cœlom.

Text-figure 1.

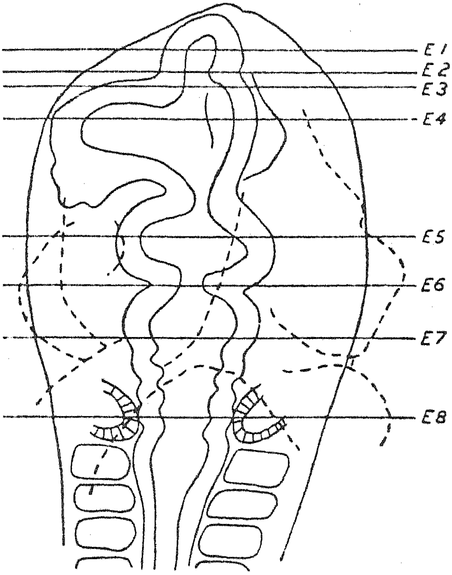


Diagram of a longitudinal horizontal section.

a. *The general proportions of the anterior end and its relations to the extra-embryonal portions of the blastoderm.*

There is a complete absence of any anterior amniotic fold, as is shown in the sections, Pl. III. fig. 4, E 1 and E 2. The lateral limiting sulci are fairly well marked (*lat.l.sul.*). There is no head-fold and consequently no anterior limiting sulcus; the ectoderm of the anterior end of the head of the embryo is continuous with that of the blastoderm immediately in front of the head without being recurved back under the latter, so as to delimit it from the blastoderm as is normally the case at this stage of development.

Whilst the cranial flexure is, in a normal chick of 15–17 somites, well marked, consisting of a bending of the antero-posterior axis of the head, and there has also occurred its partial revolution about the dorso-ventral longitudinal plane, Pl. I. fig. 3 indicates at once that the antero-posterior axis of the head of Rudiment *a* is perfectly straight, while the sections show that there is little sign of any rotation (Pl. III. fig. 4, E 1–E 5). The slight obliquity of the dorso-ventral plane, which is seen in section E 4 (fig. 4), is in the reverse direction to normal, and is no doubt the consequence of the morphological asymmetry of the head which has yet to be described.

Reference must now be made to the general dimensions and proportions of the head, features of considerable theoretical interest. Pl. I. figs. 1 and 3 show well what we may briefly characterise as the "shortness" of the head, and they further emphasise the fact that in Rudiment *a* the brain does not play the important part in moulding the general contours of the head, which is the case in the normal chick, and which is largely consequent upon the considerable dilatation of the brain vesicles.

This abbreviation of the anterior region of Rudiment *a* is due to two main causes, viz., the under-development of the Fore-Brain and the condition of the heart and fore-gut.

In the normal chick of 16–17 somites the anterior intestinal portal is situated some distance posteriorly to the auditory vesicles. In Rudiment *a*, on the contrary, the anterior intestinal portal is anterior to these (Pl. I. fig. 3 and Pl. II. fig. 5. E 8, *l.* and *r.aud.ves.*).

Now it is obvious that to describe the facts in this way is really to beg the question, for one is assuming that the auditory vesicles are normal in position.

An alteration in the relative positions of auditory vesicles and intestinal portal might result either from an abnormal development of the brain (for the auditory vesicles are normally placed in relation to the neuromeres of the hind-brain) or from an actual displacement of the anterior intestinal portal (*i.e.*, an under or over-development of the fore-gut), or it might be associated with a combination of both these factors.

By comparison of the measurements of Rudiment *a* with those of normal embryos, it seems clear that in the case of the former each of these factors plays a part in the production of the condition described.

Measurements of Normal Embryos.

Designation.	No. Somites.	Ent. Length.	(Length Ant. End—Aud. Ves.)	(Length Ant. End—A.I.P.)
N 1	16	5·5 mm.	1·6 mm.	2·1 mm.
N 2	16	6 mm.	1·5 mm.	2·1 mm.
N 3	15	6 mm.	1·4 mm.	1·9 mm.
N 4	17	6 mm.	1·4 mm.	2 mm.
Mean of Measurements of Normal Embryos.		5·9 mm. (nearly)	1·47 mm.	2·02 mm.
Measurements of Embryo *a* of Blastoderm E.	16	6 mm.	1·3 mm.	1·2 mm.

These measurements are reproduced above, and they require but little comment. The mean of the measurements taken from the extreme anterior end to the plane of the auditory vesicles is just under 1·5 mm., while the mean of the measurements from the anterior end to the anterior intestinal portal is 2·02 mm. In the case of Rudiment *a* the former measurement is 1·3 mm., the latter 1·2 mm.

Hence the intestinal portal is situated no less than ·8 mm. more anteriorly than in the normal embryo, while the length of the head, as defined by the distance between its anterior end and the auditory vesicles, is barely ·2 mm. less than normal.

It is therefore clear that the abbreviation of the head of Rudiment *a* is largely apparent, resulting from the abnormally anterior position of the intestinal portal; but is in part real, since the head, as more strictly defined by the position of the auditory vesicles, measures ·2 mm. less than normal.

b. *The nervous system.*

The nervous system is, posteriorly to the auditory vesicles, quite normal, its development only becoming abnormal in the anterior region.

All the chief divisions of the brain are clearly recognisable (Pl. I. fig. 3; Pls. II. & III. figs. 4, 5), and the five neuromeres of the Hind-Brain are quite distinct. Cranial flexure being absent, the neural axis is, of course, straight.

The degree of abnormality increases as we pass postero-anteriorly and is greatest in the Fore-Brain. This abnormality is of two kinds: firstly, a general under-development of the Fore-Brain, and, to a less extent, of the Mid-Brain; secondly, a definite bilateral asymmetry of the Diencephalon, evident particularly in the optic evaginations.

The Mesencephalon appears somewhat compressed in the sagittal plane. The Telencephalon is very small and its cavity relatively minute. (Pl. I. fig. 3 and Pl. III. fig. 4, E 1 and E 2, *Tel.*).

The asymmetry of the Diencephalon was a striking feature of the whole mount (Pl. I. fig. 3, *Dien.*) which gave the impression that the right optic evagination is entirely wanting, the left being relatively well developed and almost making contact with the ectoderm. Reference to the sections through this region (Pl. III. fig. 4, E 3 and E 4) shows that the cavity of the Diencephalon is extremely irregular in shape. The left optic evagination is well marked (*l.op.*). The Diencephalic wall in the corresponding position on the right side shows no such definite evagination, though dorso-laterally and ventro-laterally it is bent outwards somewhat suggesting commencing evaginations. The more dorsal outbulging, which is the larger of the two, would seem to represent the right optic vesicle, but if so it is very much less developed than the left, the brain in this region being markedly asymmetrical (fig. 3). A median ventral downgrowth of the diencephalic floor is well marked even in the whole mount (fig. 3, *inf.dep.*); in transverse section (fig. 4, E 4, *inf.dep.*) it is seen to approximate to a median dorsal thickening of the gut-entoderm. It is probably infundibular in nature. Further anteriorly the floor of the diencephalon becomes very thick (Pl. III. fig. 4, E 3).

c. *The fore-gut.*

Owing to the anterior position of the intestinal portal the fore-gut is relatively very short. Throughout its length it is dorso-ventrally compressed. The hyoid pouch almost makes contact with the ectoderm (Pl. II. fig. 5, E 7, *l.Hy.P.*).

The condition of the anterior portion of the gut is of extreme interest, and here, as in the case of the other organ-primordia, deviation from the normal is very great.

In the first place is to be noted the apparent absence of any sign of an oral plate, the formation of which, in the absence of any head-fold, is of course impossible. The gut is remarkable by reason of its extension forward to the prechordal region (see Pl. I. fig. 7 B). The anterior extremity of the chorda comes into relation with the dorsal wall of the gut, which latter then effects contact with the well-developed infundibular downgrowth of the Diencephalon (fig. 7 B, *inf.dep.*); this contact extends for some distance, throughout which the mid-dorsal wall of the gut is markedly thickened, showing some signs of cellular proliferation.

The most surprising circumstance is, however, that in front of this point, at which one would expect the gut to terminate, it extends for a considerable distance ventrally to the Telencephalon (Pl. III. fig. 4, E 2, and Pl. I. fig. 7 B, *Ant.ext.F.G.*), from which it is separated by a large vessel formed by the union of the two apparently dorsal portions of the mandibular aortic arches. It is only in the extreme anterior region of the Telencephalon (Pl. III. fig. 4, E 1) that the fore-gut has disappeared.

d. *Heart, vascular system, and cœlom.*

The Heart, as seen in the whole mount, is characterised by its relative shortness and broadness (Pl. I. fig. 3, *Ht.*). It presents an outwardly-directed convexity on either side. The sections show that the two endocardial tubes have completely failed to fuse, and that they are, for the greater part of their extent, widely separated. Only immediately in front of the anterior intestinal portal do they even approximate in the mid-line, and even here no fusion, *sensu stricto*, has occurred. The right heart-tube is somewhat shorter, and for the greater part of its extent its diameter is considerably less than that of the left (Pl. III. fig. 5, E 5, and Pl. II. fig. 5, E 6).

It will be seen that the condition of the heart resembles that which is sometimes described in an otherwise normal chick under the name of "double-heart," and which was elucidated by Camille Dareste (2), who showed it to result from the failure of the two heart-tubes to fuse as normally occurs.

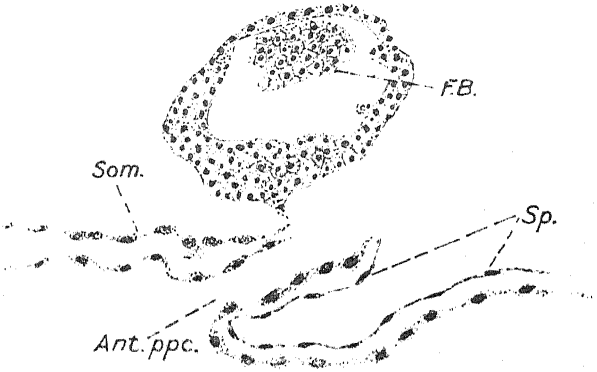
Tracing the heart-tubes anteriorly they do not fuse beneath the ventral wall of the gut to form the ventral aorta as in the normal chick, but in the region of the infundibulum, where they have become very small, they become continuous laterally with two large vessels lying on either side of the upper surface of the gut (as will be seen in the sequel, it is probable that these two dorso-ventral vessels running on either side of the gut are not morphologically the mandibular arches as one would at first sight suppose).

Anteriorly these two vessels (the right of which is the larger) pass round the median infundibular-gut junction (E 3) and fuse to form a large median aortic space lying between the Telencephalon and the prechordal prolongation of the gut (Pl. III. fig. 4, E 2, *Ant.aor.Sp.*). Posteriorly the two vessels (Pl. III. fig. 4, E 3, *R.Lat.aor.Sp.*, *L.Lat.aor.sp.*) become continuous with the dorsal aortæ (E 5–E 6, *Dor.Aor.*), which pass back on either side of the chorda in the normal manner.

The myocardium is characterised by its width; in front of the anterior intestinal portal there is a ventral myocardial septum.

With respect to the pleuro-pericardial cœlom, this is remarkable for its extreme forward extension immediately beneath the embryo, the lateral amniocardiac vesicles opening into each other and forming a median cœlomic space which extends in front of the anterior limit of the embryonal formation proper. This forward extension is permitted by the absence of the head-fold (Pl. III, fig. 4, E 1 and E 2, *Ant.p.p.c.*; text-fig. 2, *Ant.p.p.c.*), and in the sequel it will be seen to be a point of considerable morphogenetic significance.

Text-figure 2.



Transverse section through the extreme anterior region of embryonal formation α.

For explanation of letters see p. 109.

D. *Summary of the principal morphological abnormalities of the greater Embryonal Formation* (Rudiment *a*).

A. General proportions of anterior region and its relations to the extra-embryonal portions of the blastoderm.

I. Absence of an anterior amniotic fold.

II. Absence of a head-fold.

III. Absence of cranial flexure.

IV. Abbreviation of head proper as indicated by the distance between the anterior end and the plane of the auditory vesicles.

B. The nervous system.

I. Smallness and compression of the anterior two divisions of the brain, the Telencephalon and the Diencephalon.
II. Reduction of the optic evagination on the right side.

C. The gut.

I. Its shortness, in consequence of the position of the anterior intestinal portal.
II. Absence of an oral plate.
III. Thickening and proliferation of entoderm of the gut-roof contiguous to the infundibulum.
IV. The abnormal prechordal prolongation of the gut.

D. Heart, vascular system, and cœlom.

I. No fusion of heart-tubes.
II. Small size of right heart-tube.
III. Median aortic space beneath the Telencephalon.
IV. Width of pericardium.
V. Anterior extension in mid-line of pleuro-pericardial cœlom.

III. DISCUSSION.

Part A. *The Morphogenesis of Embryonal Formation α.*

It would appear advisable, before proceeding to a consideration of the ultimate origin of the two embryonal rudiments upon this blastoderm, to discuss in some detail the morphology of Embryonal Formation α, the more completely developed of the two rudiments.

Such a discussion will, I believe, result in fairly definite conclusions as to the primary factors responsible for the abnormal development of Rudiment α, and indirectly to the causes responsible for the presence upon the blastoderm of the second Embryonal Rudiment (β).

There appears to me ample justification for the view that many of the abnormalities of Rudiment α, particularly those affecting the vascular system and gut, are secondary, in the sense that they are consequent upon an inhibition of the normal development of the extreme anterior portion of the embryo, in particular of the medullary plate region.

For this abnormal arrest of the growth of the anterior region of the medullary plate the only adequate explanation would appear to be the existence of some germinal defect, which would therefore be the primary modification in the sense indicated above.

That this is indeed the case seems the only view consistent with the occurrence of the following abnormalities affecting the anterior portion, particularly the medullary plate region of the embryo:—

a. The absence of a true head-fold.
b. ,, ,, ,, an anterior amniotic fold.
c. ,, ,, ,, cranial flexures.
d. The shortness of the brain resulting mainly from the under-development of Telencephalon and Diencephalon.
e. The condition of the optic vesicles.

The assumption will therefore be made in the following pages that the primary factor responsible for the abnormal development of Rudiment *a* was this abnormal arrest of the growth of the anterior portion of the medullary plate, and the attempt will be made to demonstrate how the other structural modifications are necessary but purely secondary consequences of this initial disturbance of the "causal harmony of development" (*Driesch*).

1. *The condition of the gut.*

In the first place, we may consider the condition of the fore-gut, particularly with reference to the anterior position of the anterior intestinal portal.

It may be recollected that in the normal chick two main factors are responsible for the formation of the fore-gut:—

1. A definite forward growth of the brain.
2. The backward growth of the posterior margin of the splanchnopleuric head-fold owing to pleuro-pericardial cœlomic expansion.

It is generally agreed that the initiation of fore-gut formation is due to the development of the head-fold, which latter itself is due to the more rapid growth of the anterior part of the medullary plate.

With regard to the precise importance of these two factors there has been considerable difference of opinion, and it may now be accepted as established that the mechanism of fore-gut formation differs considerably in the various groups of vertebrates. With regard to the condition in the chick embryo, Robinson (**13**) considered that the former factor was that mainly if not solely operative. Other authors (Gräper, Rouvière, **4**, **14**) have contended that there occurs also a backward growth of the anterior intestinal portal, and it may be regarded as established that under normal conditions both these factors play a part in the formation of the fore-gut in the chick (a view which it will be seen is supported by a consideration of this embryo). On the other hand, in the marsupial *Dasyurus*, Miss Parker (**11**) has shown that the second factor plays a far more fundamental rôle.

Since in the major rudiment of blastoderm E the former factor was largely absent, it is not surprising that a condition of affairs has arisen analogous in many respects with that in *Dasyurus*, where, according to Miss Parker, the initiation of head-fold formation is due to the forward growth of the brain-plate, whilst the expansion of the pericardium is the main factor responsible for the extension of the fore-gut.

A feature which is of undoubtedly great interest is that in an embryo in which there can have been very little active forward growth (*i. e.*, in contra-distinction to general or interstitial growth) of the medullary plate, relatively to the line separating embryonal and extra-embryonal areas, which notably Robinson considered as the main factor concerned in fore-gut formation, there should be present a well-marked gut *extending anteriorly up to the anterior limit of the Telencephalon.*

That a true head-fold could never have been present is fairly evident from the sections (Pl. III. fig. 4, E 1, E 2, E 3), and accordingly it may be concluded that the second factor (pleuro-pericardial cœlomic expansion) must have been that which was mainly if not solely operative in the formation of the entire extent of the fore-gut. This is borne out by the presence of the pleuro-pericardial cœlom, separating somatopleure and splanchnopleure in the extreme anterior region of the embryo, in front even of the anterior limit of the gut itself (fig. 4, E 1, and text-fig. 2), a condition which is not found, of course, in the normal chick embryo. It is of importance, too, to note that the slight inturning of the ectoderm beneath the extreme tip of the embryo does not extend to anywhere near the anterior limit of the gut (fig. 4, E 1 & E 2; Pl. I. fig. 7 B).

It is probable, therefore, that in this embryo even the initiation of fore-gut formation was due to the formation of the pleuro-pericardial cœlom. There must have been an extension in towards the middle line, and a subsequent union of the amnio-cardiac vesicles, thus producing a condition somewhat similar to the pleuro-pericardial canal of mammals. Expansion of the pleuro-pericardial cavity so formed in the posterior direction would result in the formation of a splanchnopleuric or cardiac fold and a fore-gut.

Now it will be recollected that the apparent length of the fore-gut as determined by the position of the anterior intestinal portal is 1·2 mm., as compared with a normal length of about 2·1 mm. This seems to indicate that while in normal morphogenesis the active forward growth of the brain plays a part in the increase in length of the fore-gut, the absence of this factor in specimen E must have influenced unfavourably the action of pleuropericardial expansion, resulting in an unduly slow progression backwards of the cardiac fold, and an abnormally short fore-gut, which is therefore a secondarily induced condition resulting from the primary abnormality of the medullary plate.

2. *The condition of the heart-primordia.*

The earlier processes in the development of the heart stand in intimate causal relationship to fore-gut formation, and one naturally turns therefore to a consideration of the condition of this organ.

The two heart-tubes lie side by side beneath the fore-gut, and are widely separated for the greater part of their length, actual fusion having occurred at no point. No doubt this condition results from the shortness of the fore-gut and the correlated great width of the pericardium (Pls. II. & III. fig. 4, E 5, fig. 5, E 6, E 7), since this is clearly in harmony with the view expressed by Miss Parker (**11**) that the approximation of the heart-tubes is due to the growth in length and decrease in width of the pericardium which, under normal circumstances, occurs at this stage.

In this connection the phenomenon of so-called "double heart," which sometimes occurs in otherwise apparently normal embryos, seems of interest. In the few examples of this condition which I have had the opportunity of examining, the "duplicity" of the heart, really, of course, a non-fusion of the two heart-tubes, has been associated with an unusually anterior position of the cardiac fold, a condition which we should expect to be always present if the above view as to the cause of the approximation and fusion of the heart-tubes be true.

It has been mentioned that in this specimen the right heart-tube is of considerably less diameter than the left, while in the normal chick the reverse is the usual condition; it has been suggested by Miss Parker (**11**) that this condition is a precocious indication of heart-curvature, the lesser limb becoming the concave border of the heart. With reference to the apparent anomaly of specimen E, it may be recalled that (*a*) occasionally in the chick, flexure of the heart is to the left instead of to the right; (*b*) that the condition here is possibly a functional or physiologically induced asymmetry, which seems to be the more likely explanation.

In this connection it is of interest to note that Wilder (**19**) has pointed out that a second cause of "deformity," at least as regards bilateral symmetry or equality of components, and one that is specially operative in assisting the secondary deformation of a diplopage, is found in the striving among the parts during growth for the best physiological efficiency. This is particularly notable in the unequal degree of development often seen in the duplicate systems of organs (particularly those functional from an early period, *e.g.*, the circulatory and digestive systems) possessed by a diplopage.

This inequality of the heart-tubes may perhaps be regarded, then, as an instance of the capacity of the various organs of the body to undergo morphological changes in response to altered physiological conditions, comparable, say, with such a common pathological condition as the cardiac hypertrophy and dilatation induced by valvular incompetence. The inducing cause would be the primary asymmetry of the head and fore-brain (see Pls. I. and II. figs. 3, 4, E 3 & E 4), owing to the under-development of the fore-brain and optic evagination on the right side.

Congestion has taken place on this side, as is evinced by the greater size of the right mandibular arch. The greater resistance to the flow of the blood on the left side, owing to the smaller size of the vessels, has led to a congestion in the left ventral aorta and heart-tube, hence its greater diameter.

3. *The anterior portions of the fore-gut and vascular system.*

There yet remain for consideration the anterior portion of the fore-gut and its relations to the central nervous system.

Firstly, with reference to the absence of an oral plate, a glance at the figure of the longitudinal section (Pl. I. fig. 7 B) will make quite clear the impossibility of a fusion between the anterior gut entoderm and adjacent ectoderm such as normally occurs, since here the pleuro-pericardial cavities, which normally fuse in the mid-line posteriorly to the oral plate (fig. 7 A, *p.p.c.*), in this case extend to the anterior end of the fore-gut and to some considerable distance in front of it (Pl. III. fig. 4, E 1–E 4, Pl. I. 7 B, *p.p.c.*), indeed for some distance in front of the anterior end of the embryo itself: this is a definite median cœlom, formed presumably by the fusion in the mid-line of the lateral cœlomic cavities.

There is, indeed, no sign of any thickening of the floor of the fore-gut in the region where one would expect fusion between entoderm and ectoderm, were it possible to take place.

It will be remembered, however, that there is a very marked thickening and proliferation of the median gut-roof adjacent to the infundibular region of the fore-brain (Pl. III. fig. 4, E 3, E 4, Pl. I. 7 B), and if this entodermal thickening be regarded as the protochordal plate complex, we can, I think, consistently interpret the condition of the fore gut and its relations to nervous and vascular systems with reference to the normal morphological relations of these parts.

In Pl. I. fig. 7 B is given a semi-diagrammatic reconstruction of a median longitudinal section of the major embryonal formation of Blastoderm E alongside, for the purpose of comparison, of a similar sagittal section of the anterior region of a normal embryo of about the same age (fig. 7 A).

It will be recollected that in the normal chick the entoderm of the roof of the extreme anterior end of the fore-gut is somewhat thickened in the vicinity of the termination of the chorda and the floor of the diencephalon, a slight diverticulum in this region forming the so-called prechordal gut or Seessel's pocket, while an entodermal thickening situated ventrally comes into relation with the ectoderm to form the oral plate. The depression of the oral plate beneath the ventral surface of the head is increased as development progresses by the growth of the brain and the occurrence of the cranial flexures. The two lateral components of the mandibular aortic arch meet in the mid-line just behind the posterior limit of the oral plate to form the median ventral aorta (fig. 7 A, X').

Now, on the assumption that in Rudiment *a* the dorsal thickening of the gut-wall in the infundibular region represents the protochordal plate, interesting deductions follow as to the morphological relationships of the associated parts. In the first place, it follows that that portion of the thickened gut-roof immediately in front of the point where the latter makes contact with the infundibular region of the Diencephalon must be regarded as the equivalent of the entodermal moiety of the oral plate of the normal chick: and further, that portion of the thickened entoderm immediately posteriorly to this as the morphological anterior limit of the gut, *i.e.*, the prechordal gut (Seessel's pocket) of the normal chick (Pl. I. fig. 7 A).

If this interpretation be correct, we must conclude that the singular anterior prolongation of the gut, which is well shown both in the transverse and longitudinal sections (fig. 4, E 2, and fig. 7 B, *Ant.ext.F.G.*), is morphologically (*i. e.*, in reference to the normal condition) a part of ventral gut entoderm, and that that portion of the gut-roof which extends from the point of contact with the infundibulum to its topographical anterior end Z (fig. 7 B), and which is therefore apparently dorsal, is morphologically ventral, being the equivalent of that part of the gut-floor of the normal embryo which extends from the posterior limit of the oral plate to, say, the point Z′ (fig. 7 A).

The dispositions of the anterior portions of the aortic system can only, it seems to me, be consistently interpreted on this view. The median vessel between the telencephalon and the anterior prolongation of the gut (fig. 4, E 2, *Ant.aor.sp.*) is formed by the union of the continuations of the two dorsal aortæ which pass round the infundibular-gut connection; ventro-laterally it is continuous with the anterior continuations of the two lateral heart tubes.

Now there seems to be no room for doubt that this median vessel X (fig. 7 B) must be regarded as morphologically the median *ventral* aorta X′ (fig. 7 A), the portions of dorsal aortæ which pass round the infundibular-gut connection to open into it represent the mandibular arches, while a most significant fact is the absence of any fusion between the anterior continuations of the two heart-tubes on the apparent or topographical ventral side of the gut.

The portion of the gut-wall with which this median aortic space is in immediate relation, though apparently dorsal, corresponds, it must be recollected, to that part of the entoderm which forms a part of the floor of the gut of the normal chick.

These modifications of the normal morphology of the head no doubt result from the absence of the normal growth zones of the anterior end of the medullary plate and brain.

1. Primarily, the absence of normal head-fold formation inhibited the possibility of any conjunction of the entoderm of the fore-gut with ventral head-ectoderm to form an oral plate.

2. The presence of a considerable part of what should normally

have constituted the anterior floor of the gut, beneath the fore-brain as a prechordal prolongation of the gut, resulted from the fact that gut-formation was effected by the formation and expansion of the pleuro-pericardial cœlom alone and not by head-fold formation. This is evinced by the anterior extension of the median pleuro-pericardial cavity (fig. 7 B, *Ant.p.p.c.*).

3. The retention of this original condition was no doubt a result of the absence of the normal expansion and flexure of the fore-brain. This latter, in the normal embryo, it must be recollected, conditions, largely, the depression of the oral plate beneath the ventral surface of the head; and had the growth of the fore-brain occurred in the usual manner in this case, no doubt it would have tended (though it seems doubtful whether it would have succeeded in effecting this) to drag round at least a portion of the apparently dorsal wall of the pre-infundibular gut (fig. 7 B, *Ant.ect.F.G.*) into a ventral position.

Part B. *The Origin and Relationship of the Two Embryonal Rudiments.*

There seem good grounds, then, for the conclusion that the structure of embryonal Rudiment *a* is only explicable as resulting from a very early germinal defect, affecting in particular, it would seem, the anterior medullary plate region. Turning now to the anterior rudiment, designated in the descriptive part as Rudiment *β*, this can only be described as primitive streak-like, so far does it deviate from the normal. There would seem here to be no question but that it must have taken origin from a very defective germinal centre compared with that from which a normal embryo is derived.

Blastoderm E, then, must have been characterised from a very early stage by the presence of two germinal centres, both defective presumably, in the sense that they must have lacked some portion of the germinal or formative material present in the normal germ.

It is proposed to consider here, as briefly as possible, the probable mode of origin of this digerminal blastoderm.

In the first place, it may be emphasised that while all di-embryonal blastoderms must have been characterised at an earlier stage by the presence of two germinal centres, Specimen E differs from the great majority of those hitherto described in the important respect that each of these germinal centres must have been *defective*, and in this section we shall be concerned almost solely with demonstrating that this defectiveness results from the mode of origin of the two centres, and is only explicable on the supposition of a certain mode of origin.

Twinning or duplicity is of two main types, to which the terms Dizygotic and Monozygotic have been applied, practically all the multitudinous theories which have been suggested falling into one or other of these two categories. The former signifies the development in proximity of two embryos, each derived from a fertilised ovum. In this type secondary fusion may or may not occur. The latter signifies the development of two more or less complete individuals from a single fertilised ovum, and involves, of course, a process of fission or separation of the original germ into two more or less autonomous centres of embryonal formation. Either type may be specific, as in the armadillo, or merely abnormal and sporadic, as in the chick and man. Both types have been experimentally induced in lower forms, the former in particular by Driesch and Metschnikoff (**3**, **9**), who have succeeded in producing a single larva from the fusion of two eggs or young larvæ, the latter by numerous investigators.

As to which mode of twinning is responsible for the production of the diembryonal blastoderms which are of so common occurrence in the chick, there would seem to be no general agreement, both seem possible *a priori*, and the conclusions of the majority of authors hitherto, seem to be mainly surmise. Advocates of the former theory in one or other of its numerous forms have been the Hertwigs, Weidman and Tur, Broman, Windle, Panum, Klaussner and Marchand, and of the latter numerous authors including in recent times, Bateson, Kaestner, Wilder, &c.

The present specimen seems of extreme interest as leaving no room for doubt between these two alternatives.

The following features of the blastoderm, considered in conjunction, seem to indicate such a close morphogenetic relationship between the two embryonal rudiments as can only be construed as due to their having taken origin from an originally single germinal centre, presumably by some process of fission or division which resulted in the physiological autonomy of the two secondary centres.

1. The regular outline of the blastoderm as a whole, which shows no sign of division into two portions.
2. The continuity of the germ-layers in the various regions of the blastoderm, and the continuity of the lateral cœlomic spaces in the region of Rudiment β with those in the region of Rudiment α.
3. The development of the two embryonal rudiments on a single longitudinal axis. The axis of the "primitive groove" of Rudiment β is situated on the anterior continuation of the median axis of Rudiment α (see Pl. I. fig. 1).

   Further, along that portion of the longitudinal axis between the two rudiments the median band of unsplit mesoderm forms what may be regarded in a sense as a differentiated connection between the two rudiments, forming a conclusive indication that they are indeed developed on what is strictly a single primary morphogenetic axis. In other words, the two embryonal rudiments must have arisen from the original centre subsequently to the laying down or, at all events, to the determination of the primary longitudinal axis.

It may here be noted that this blastoderm would seem to fit in well with C. M. Child's theories of development and reproduction by the physiological isolation of parts (**1**).

4. It has been pointed out above that the primary nature of the abnormality of the two rudiments is a lack or deficiency, and it would seem that this deficiency must be regarded as reciprocal. While the posterior parts of Rudiment *α* are quite normal, the amount of disturbance increases as we pass anteriorly. From section A of the discussion it was concluded that the seat of the primary disturbance was the extreme anterior region of the embryo, in particular of the medullary plate. The inference seems fairly natural that Rudiment *β* represents that portion of the germinal substance which was lacking in the extreme anterior portion of Rudiment *α*. Expressed in terms of Child's theories, one would say that that portion of the germ from which Rudiment *β* developed came to lie outside the range of dominance of the primary centre, and thus becoming physiologically isolated, commenced to develop as an independent centre. According to Child (**1**), "Parts of the individual may come to lie beyond the range of dominance in consequence of increase in size of the whole, of decrease in range and degree of dominance by decrease in the metabolic rate in the dominant region, of decrease in conductivity of the paths of correlation, and of the direct local action of external factors which increase the independence of subordinate parts." The factors responsible for the initiation of the secondary centre of embryo formation on blastoderm E must presumably have been somewhat of the nature of the second and fourth of these, or of a combination of the two. The more likely explanation would seem to be that the primary disturbance involving the anterior medullary plate region, or more strictly (since it must have occurred at a very early period) the apical region of the major axis, led to the defective development of the anterior portion of the central nervous system, with the secondary modifications of Rudiment *α* discussed in Part A above. On the other hand, the abnormal development of the anterior end of Rudiment *α* would have been accompanied by a decrease of "metabolic rate," and hence in the range of dominance with the consequent isolation of Rudiment *β* as a secondary germinal centre.
5. While, as emphasized in 3 *supra*, the two rudiments clearly lie on a single long axis, it will be noticed that this axis curves somewhat to the left in the region of Rudiment *β*. It seems possible that this fact may be correlated with the morphological asymmetry of the head of Rudiment *α*, which is more defective on the right side (see Pls. II. & III. figs. 3, 4, E 3 and E 4). These two facts suggest an obliquity of the original disturbance in relation to the major axis.

There are two features of the blastoderm which seem to require further brief comment:—

a. The significance of the primitive streak-like character of Rudiment β.

b. The relatively great distance separating the two embryonal rudiments.

a. Experimental work on the localization of the prospective embryo upon the unincubated blastoderm and the relations of the primitive streak to the future embryo have shown that the primitive streak furnishes material for the development of those regions of the latter lying posteriorly to the heart, while, on the contrary, "the material of the primitive streak does not enter into the formation of the brain" (Peebles, **12**).

But obviously it does not follow that the converse must hold, *i. e.*, that material from which the brain normally arises, may not under certain circumstances have the power of giving rise to a primitive streak-like structure or tissue. Judging from the analogy of lower forms, one might expect that it would have this power, though it is important to recollect that, as Child points out, the limitation of the capacity of reconstitution, *i. e.*, of the potentiality of the germ, is more or less progressive from lower to higher forms.

In any case, owing to the conditions under which the development of the chick takes place, its experimental demonstration would be a matter of extreme difficulty. Nevertheless, the primitive streak-like nature of Rudiment β appears without doubt indicative of its physiological isolation, *i. e.*, that it is developing, or "endeavouring" to develop, if one may be permitted this teleological but expressive phrase, as a whole.

For, to pursue the analogy with lower forms, gastrulation and primitive-streak formation resemble each other in this, that they are each, the one in the holoblastic, the other in the meroblastic egg, the earliest fundamental morphogenetic process by which the long axis of the body is determined.

Hence the earliest obvious act, by which a physiologically isolated part of a holoblastically developing embryo is seen to be developing as a whole, is the more or less successful attempt at gastrulation.

In the same way the formation of a primitive streak-like structure—however imperfect—by a group of blastomeres upon a blastoderm must surely be regarded as indicative of their physiological isolation, that is, of an attempt to develop as a whole, however limited their capacity to do so.

b. With respect to the second point, *a priori*, there would appear no grounds for supposing that the effect of the initial disturbance would be limited to the embryonal portions of the blastoderm. At the early stage at which the disturbance must have occurred, there can hardly have been any sharp distinction between the embryonal and extra-embryonal portions of the blastoderm: hence the presence of a second centre of embryonal formation clearly implies the existence of a region of blastodermic extension and growth in correlation with it, quite distinct from that related to the main embryonal rudiment (Rudiment *a*). The existence of such a centre also explains the great length of the blastoderm as a whole, composed as it is of two adjacent areas of blastodermic extension lying along one longitudinal axis, and further explains the great separation of the two rudiments, since the rate of extension of that portion of the blastoderm lying between them must of necessity be considerably greater than in any other area, for here there is increase of blastodermic extent in relation to each of the embryonal formations.

IV. TERATOLOGICAL SIGNIFICANCE.

1. *Bearing on the nature of unequal monstrosity,* "Duplicitas asymmetros."

Unequal double monsters are those in which the two components show marked dissimilarity in the degree of their development. They are best known in mammals, particularly in man, in which numerous types have been recorded. There appears, however, to be little knowledge as to the earlier stages of these forms of double monstrosity, hence little would seem to be definitely established as to their mode of development, though there has been considerable speculation on these questions. Very few cases of unequal double monstrosity in birds seem to have been put upon record, and here, too, little is known as to their mode of origin and development. Kaestner, one of the foremost students of double monstrosity in birds, remarks **(6, 7)** that, "Ueber die embryonale Entwicklung parasitären oder, wie man sie auch nennt, asymmetrischen Doppelbildungen wissen wir wenig"; while Wilder **(18)**, speaking of mammals, said: "To my knowledge this form of monster has never been studied for the purpose of testing whether or not the two components were ever originally physical duplicates."

The accurate definition of unequal double monstrosity is a matter of some difficulty in the absence of knowledge as to their mode of origin and development.

Geoffroy St. Hilaire, who placed them in the second order of his group of "Monstres Doubles," characterised them as follows **(15)**:—

"Monstres doubles parasitaires ou composés de deux individus très-inégaux et très-dissemblables l'un complet ou presque complet, analogue à un autosite; l'autre non seulement beaucoup plus petit, mais très-imparfait, analogue à un omphalosite ou même à un parasite, par conséquent incapable de vivre par lui-même, et se nourissant aux dépens du premier dont il n'est physiologiquement qu'un simple appendice."

According to Wilder (**18**): "These monsters consist of two components of very unequal development, the one (autosite) being normal or nearly so, and the other (parasite) quite incomplete and attached to the first as a dependent growth usually adhering to some point on the ventral side."

Schwalbe (**16**) defines them as: "Die asymmetrischen Doppelbildungen, die zweite grosse Hauptgruppe der Doppelmissbildungen, sind dadurch characterisiert, dass ein Individualteil eine bedeutend geringere Ausbildung aufweist (Parasite) als die andere, vollig ausgebildete (Autosite)."

Kaestner (**6**, **7**) more briefly speaks of them as, "Doppelbildungen mit unsymmetrisch gelegenen oder ungleichmässig entwickelten Komponenten."

It is instructive to compare these definitions: the latter three, those of Wilder, Schwalbe, and Kaestner, it will be noted, are based purely on morphological data, in striking contrast to the original definition of St. Hilaire, which was based also on a physiological conception, that of nutrition. This latter is now clearly inadmissible, and in any case was only rendered possible by the lack of early stages. The only strictly valid definition and classification of unequal monstrosity would be based not on physiological, or even on morphological, but on morphogenetic data, in other words on ontogeny, just as there is only one natural classification of animals, that based on phylogeny.

In other words, the only rational or natural classification must be based on a consideration of past history, and through that of causality.

Now the fundamental principles which are raised by a consideration of the morphogenesis of asymmetrical duplicity appear to be first, the relationship of the two centres at their time of origin, and secondly, the possibility and extent of a subsequent modification of these relations due to secondary causes, which may or may not act in such a way as to obscure the original condition. Obviously the rational classification of double monstrosity will only be founded on the fullest possible enlightenment as to the former of these questions, which in turn can only follow from a knowledge as to the extent and nature of secondary modification. The essential problem was appreciated by Wilder in the passage quoted above, "this form of monster has never been studied for the purpose of testing whether or not the components were ever originally physical duplicates."

The question is, after all, merely an aspect of a wider one which has been stated as the "ontogenetic permanency of teratological organisation." With reference to this, Stockard (**17**), speaking of the cyclopean condition, says: "the cyclopean defect is present from the first in the same condition as it will continue throughout development."

With regard to the origin of unequal duplicates, most writers hitherto seem to have inclined to the opinion that they were originally physical duplicates, the asymmetry resulting from secondary deformation. Thus Wilder in his earlier paper (**18**) advanced this opinion, basing it partly on the fact that where it is possible to determine the sex of the "parasite," "it seems always to be the same as that of the autosite." In his later paper he seems to have modified somewhat his earlier views, "all are not necessarily deformed."

The discussion may no doubt become somewhat pedantic unless it be constantly borne in mind that the numerous morphological types of unequal duplicates must almost certainly differ considerably in their ultimate origin. "Für jede Forme, eine Spezieluntersuchung eintreten" (Schwalbe).

On the other hand, were we in a position to establish a classification of unequal monstrosity based upon their morphogenesis, the most fundamental distinction that could possibly be made would almost certainly be that between those which did and those which did not arise from like centres, assuming for purposes of argument that both of these types do in fact occur.

Bearing in mind that the present discussion is concerned with the avian blastoderm, we may venture, then, to postulate three fundamental problems raised by a consideration of unequal monstrosity.

1. Can the two embryonal centres of an asymmetrical duplicate be explained as arising ultimately from a single, normal centre? In other words, is their nature dizygotic or monozygotic?
2. At their time of origin are the two centres like or unlike?
3. In the latter case—

   (*a*) What are the causal factors responsible for the dissimilarity of the centres?

   and

   (*b*) What is the relation between the dissimilarity of the centres and the production of the two centres from an originally single centre?

   In other words, is there any direct causal connection between duplicity and asymmetry?

Now, clearly, could a definite answer be given to these questions in every well defined case of asymmetrical duplicity that is placed upon record, we should be far advanced towards a comprehension of the main types of these, and of their morphogenesis.

The answer to these questions, as far as the blastoderm described in this paper is concerned, seems fairly definite, if the conclusion arrived at in section B *supra* be valid. There it was concluded:

1. That the blastoderm was certainly monozygotic.

2. That the two embryonal centres were, from the earliest period, dissimilar.
3. That the dissimilar potentiality of the two centres almost certainly resulted from their mode of origin, *i.e.*, from a qualitatively unequal division of the "formative substance" of the original germ.

Here, then, we have at least one well-defined morphogenetic type of asymmetrical duplicity, that which owes its essential characteristics to the production of two daughter centres of unequal potential from, in the first place, a single and presumably normal centre. It seems impossible that the two embryonal rudiments on this blastoderm can ever, to adopt Wilder's terminology, have been "physical duplicates."

It is not possible in this paper to enter into a comparative discussion of unequal monstrosity, even in the very restricted field of avian teratology. In few cases have instances of unequal monstrosity in birds received sufficiently detailed description to make this a fruitful undertaking, however desirable. But at least this may be said:—

That there are at least one or two cases of unequal monstrosity which must have resembled Blastoderm E in their mode of origin so closely as to belong to the same morphogenetic type. Such would appear to be—

(*a*) A goose blastoderm described by Grundman (**5**) and quoted by Schwalbe (**16**).

(*b*) Three chick embryos described by Dareste (**2**) and also quoted by Schwalbe.

(*c*) Possibly a blastoderm described by Kaestner (**6**) consisting of a normal chick embryo of 17 (?) somites, *laterally* to which occurred a primitive streak-like rudiment, closely resembling, according to his figure, Rudiment β of Blastoderm E. There was apparently no sign of any differentiated morphological connection between the two rudiments.

The blastoderms described by Grundman and Dareste resemble each other and differ from Blastoderm E in that the lesser embryonal rudiment has attained a considerably higher degree of development than is the case in the latter.

In all these cases the lesser rudiment is characterised by the extreme deformation and lack of development of the head and by the absence of the heart. In none of these cases is there any description of sections. Fortunately, however, I happen to have in my possession a blastoderm which appears to resemble these closely, and as it appears not devoid of interest, I hope shortly to have the opportunity of describing its structure.

It may be noted here that Blastoderm E appears unique among described cases of Duplicitas asymmetros in an important and significant respect. That is the fact that the greater embryonal formation ("autosite"), as well as the lesser, exhibits extreme defects of organisation. It is unnecessary to comment further here upon this interesting fact, for its morphogenetic significance was more or less directly considered in Part III. One may merely emphasize here that it is this characteristic which directly and indirectly affords strong evidence as to the mode of origin of the blastoderm, and further, that while this fact is morphogenetically of the utmost significance, it indicates no fundamental difference between this specimen and other forms of asymmetrical duplicity as regards their ultimate mode of origin.

Apart from the blastoderm referred to above, there are a number of cases on record, the significance of which appears far more uncertain; it would seem difficult even to arrive at a definite conclusion as to whether they can be regarded as monozygotic in origin. Such, for instance, are blastoderms upon which occur two embryos, both of which are morphologically normal, but which are very unequal in their degree of development as indicated by the number of somites. Such forms, it would seem, admit of equally plausible explanation, on either the Dizygotic or Monozygotic hypothesis. In the former case the explanation of the difference of age of the two rudiments is clear; in the latter they might perhaps be regarded as arising from a merely quantitative unequal division of the germ, such that each centre received its full complement of "formative substance," yet the two centres were quantitatively unlike in such a way as to result in a retarding of the development of one of them.

If this mode of origin be regarded as likely, we then appear to be able to distinguish three main morphogenetic types of duplicity:

Type 1. In which the original disturbance of the germ results in the production of both quantitatively and qualitatively like daughter centres, giving rise to the equal duplicity, the well-known type of Duplicitas symmetros.

Type 2. In which the two daughter centres are quantitatively unlike, but qualitatively similar, giving rise to two embryos both morphologically perfect but unequal in their stage of development.

Type 3. In which the daughter centres are both qualitatively and quantitatively unlike, giving rise to such a form as Blastoderm E, in which either, or even both, embryonal centres exhibit gross abnormalities of structure, apparently always of the nature of a defect of organisation.

The question of modifications and deformations of a secondary nature is too complex and lengthy to be dealt with here; it may, however, be again emphasized that it is of extreme importance in the elucidation of the ultimate mode of origin of asymmetrical duplicates.

2. *Conclusions.*

1. Blastoderm E appears unique among hitherto described chick blastoderms exhibiting asymmetrical duplicity, in that both, not merely one, of the embryonal formations exhibit gross morphological defects.

2. The morphology of Blastoderm E seems only to be explicable on the monozygotic theory of origin, *i.e.*, that both centres originated through some kind of disturbance, the exact nature of which is at present obscure, from a single and possibly normal germ.

3. The two centres of embryonal formation, to which the original disturbance gave rise, must have been from their origin, qualitatively and quantitatively, of unlike potential.

4. The primary modification induced in the greater embryonal formation resulted in the inhibition of the normal growth of the anterior portion of the nervous system and of the formation of the head-fold.

From this primary modification, indirectly followed various secondary modifications, due to the causal correlation of the various organ-primordia of the embryo.

5. While in the normal chick both the anterior growth of the medullary plate and the pleuro-pericardial expansion are operative in the formation of the fore-gut, the importance of the latter factor is indicated by the condition of embryonal formation *a*, in which, though no true head-fold could have been present, there is nevertheless a well-developed fore-gut.

6. Blastoderm E appears of extreme interest with reference to the localisation of the "formative material" in the early chick blastoderm. For while it has been experimentally demonstrated that the material of the primitive streak does not enter into the formation of the brain, it appears that, on the other hand, the material from which the anterior region of the medullary plate normally arises may under certain circumstances have the power of giving rise to a primitive streak-like mass of tissue.

7. Blastoderm E seems to have an important bearing on the *problem of the origin and nature of asymmetrical duplicity.*

There has hitherto been difference of opinion as to whether the two members of an asymmetrical duplicate could or could not have been originally (to use Wilder's term) "physical duplicates."

Opinion hitherto has inclined to the view that in the majority of cases this was the case, the inequality of the two components resulting from secondary causes. Authors, however, have recognised the difficulty of the problem and the lack of any conclusive evidence.

It is of extreme interest, therefore, to find in Blastoderm E a case of unequal duplicity in which there can be no room for doubt that the two embryonal formations were from the first unlike, the asymmetry therefore being intimately bound up with the actual origin of the two centres of embryonal formation from a single centre, and not resulting from secondary modification during the course of development.

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EXPLANATION OF THE PLATES.

REFERENCE LETTERS.

A.I.P. =anterior intestinal portal.
Ant.aor.sp. =anterior aortic space.
Ant.ext.F.G.=anterior extension of fore-gut.
Ant.p.p.c. =anterior extension of pleuro-pericardial cavity.
Ch.d. =chorda dorsalis.
Dor.aor. =dorsal aorta.
Dien. =Diencephalon.
End. =entoderm.
F.B. =fore-brain.
F.G. =fore-gut.
H.B. =hind-brain.
Ht. =heart.
Inf.dep. =infundibular depression.
Lat.l.sul. =lateral limiting sulcus.
L.aud.ves. =left auditory vesicle.
L.Ht.T. =left heart-tube.
L.Hy.P. =left hyoid pouch.
L.lat.aor.sp. =left lateral aortic space.
L.op. =left optic evagination.
Mesenc. =mesencephalon.
Mes.som. =mesoblastic somites.
Om.mes.v. =omphalomesenteric vein.
O.p. =oral plate.
P.p.c. =pleuro-pericardial cavity.
Pr.g. =" primitive groove."
R.aud.ves. =right auditory vesicle.
R.Ht.T. =right heart-tube.
R.Hy.P. =right hyoid pouch.
R.lat.aor.sp. =right lateral aortic space.
R.mes.pro. =right mesodermal (?) proliferation.
Rud. α, *Rud. β* =Rudiments α & β.
Som. =somatopleure.
Som.mes. =somatic mesoderm.
Sp. =splanchnopleure.
Sp.mes. =splanchnic mesoderm.
Tel. =Telencephalon.

Pl. I. fig. 1. Photograph of the Blastoderm, stained with Borax carmine and mounted in balsam.

Pl. II. fig. 2. Transverse section of the primitive streak-like Rudiment β.

Pl. I. fig. 3. Semi-diagrammatic representation of the anterior (cephalic) region of embryonal formation *α*.

Pls. II., III. figs. 4 & 5. Transverse sections of the anterior (cephalic) region of embryonal formation *α*.

E 1. In the plane of the telencephalon.
E 2. Posterior to E 1 in the region of the anterior extension of the fore-gut.
E 3. In the anterior region of the diencephalon.
E 4. Through the diencephalon, showing the left optic evagination, and the infundibular depression.
E 5. In the region of the mid-brain, showing the dorsal aortæ and the heart-tubes.
E 6. Posterior to E 5.
E 7. In the region of the hind-brain.
E 8. Through the plane of the auditory vesicles and the anterior intestinal portal. (See also text-fig. 1, p. 87.)

Pl. I. fig. 7. A. Diagrammatic representation of a median longitudinal section of the anterior region of a normal chick embryo of 13 somites (after Lillie, "The Chick," fig. 67). For comparison with B.

B. Diagrammatic reconstruction of the median longitudinal section of the embryonal formation *α*. For comparison with A.

10. Some Points in Insect Mechanics.

By H. R. A. MALLOCK, F.R.S., F.Z.S.

[Received March 18, 1919 : Read March 18, 1919.]

(Text-figures 1–8.)

In books on Natural History and on the anatomy of animals the descriptions are chiefly concerned with generic or specific characters, and little attention is paid to the mechanical features of the various parts of the organisms. The mechanics of joints and muscles, however, are not without interest, although the similarities are so close over a wide range of orders that they do not—with few exceptions—form a sufficient basis for purposes of classification.

Taking the whole range of animal life there is a broad distinction, in the mechanical sense, between those types which have internal skeletons (*i. e.*, vertebrates) and those where the skeleton is external (*i. e.*, insects and arthropods). In both the chief use of the skeleton is to form a more or less rigid base for the attachment of the muscles (especially the muscles of locomotion), but the form of the joints on which the muscles operate is very different in the two cases.

Joints may be conveniently classified by their degrees of freedom. The most general freedom which any two connected parts of a structure can have with reference to one another is that each can be both relatively displaced, and also turn about three axes at right angles to one another. With joints only the rotational freedom need be considered, and therefore the greatest number of degrees of freedom for a joint is three. Such joints are met with in the case of vertebrates, as, for example, at the shoulder, which allows the arm to be raised or lowered in a forward or sideways direction, and also to turn about its own axis relatively to the shoulder. The elbow-joint has two degrees of freedom, namely, so as to alter the angle between the fore-arm and the humerus, and to turn the wrist about the mean axis of the radius and ulna. The last two joints of the fingers are examples of joints with one degree of freedom only.

The jointed parts in vertebrates are kept in position by what may be compared to an elastic stocking composed of ligaments, and the working surfaces of the bones are kept from actual contact by a thin cushion of cartilage. The elasticity of the connection makes the "degree of constraint" (*i. e.*, the limits which the motion, other than that appropriate to the degree of freedom, cannot exceed) rather lax, and for this reason the vertebrate-joint can bear accidental strains without the injury which a more rigid constraint would induce.

The animals whose skeleton is external are not so favourably circumstanced in this respect. None of their joints have more than two degrees of freedom, and in general only one. The attachment of the jointed parts is made by a very short, flexible ligament which joins processes on each, and may be compared with two tubes connected as shown in text-fig. 1, the tubes representing the skeleton of the part. Such a joint has only one degree of freedom, and the constraint is very close *.

The close constraint imposed by these connections makes the joints rather liable to damage from accidental forces, and it seems probable that the limit to the size to which articulate animals can be developed is in a great measure determined by the brittleness which necessarily follows this type of construction.

Text-figure 1.

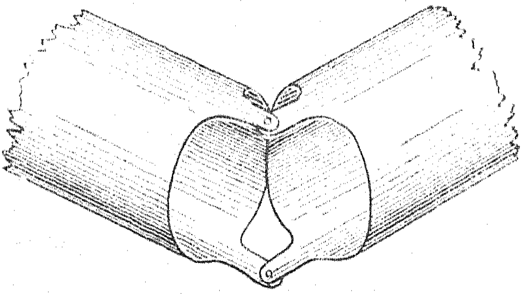

Diagram of typical Arthropod joint.

When a moving body is suddenly stopped, as when striking the ground after a fall, the forces called into play are proportional to the mass of the body, and if the force is so applied as to tend to turn a limb in any direction except that in which it is properly intended to move, the reaction at the joint, *i.e.*, the force tending to break the ligament, will be, for similar structure, in the ratio of the mass to the square of the linear dimension—or, in other words, the chance of breakage decreases directly with the size.

The great difference between the size of the largest articulate and largest vertebrate rather bears out this view.

The heaviest land † arthropod—a beetle—may weigh something over an ounce, and an elephant 4 or 5 tons. Some of the aquatic articulates—crayfish, I believe—weigh 30 pounds, and of the aquatic vertebrates, whales approach 100 tons.

Where more than one degree of freedom is required in the limb of an articulate, this object is generally attained by placing two or more joints of one degree of freedom in close succession, and in nearly all cases the legs are thus constructed, the joints of the coxæ, trochanter, and femur being close together with their axes mutually set at right angles. Text-fig. 2 shows diagrammatically the typical arthropod leg. The leg is supposed to be extended into a straight line, though in most cases the natural limitations of the motion of the joints would prevent such an extension being actually accomplished. In insects with folding wings two degrees of freedom are obtained in the same way by two closely approached joints at the base of the wing.

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* I am informed by Dr. Calman that in the leg-joints of some crustaceans one of the connections sketched in text-fig. 1 is absent, so that in these cases the joint allows partial freedom of two degrees.

† Excluding Land-Crabs.

The locomotive muscles of insects offer many points of mechanical interest. As far as the legs are concerned, the same forms of muscles and muscular attachments are found not only in insects but in all arthropods with well-developed joints, and this can be readily examined in the legs of the large crustaceans; but in insects which have a head, thorax, and abdomen, the chief locomotive muscles are all contained in the thorax, which may be compared with the engine-room of a ship, the head corresponding to the conning tower, and the abdomen to boiler-room, stokehold, and repair outfit.

Text-figure 2.

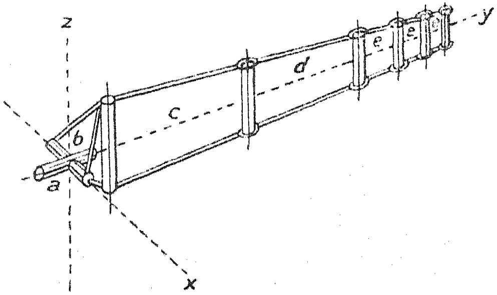


Diagram of typical Arthropod leg:
(*a*) coxa, (*b*) trochanter, (*c*) femur, (*d*) tibia, (*e*) tarsi.

It was said at the beginning of this note that the mechanical details of animals with external skeletons rarely offered characters adapted for the purposes of classification.

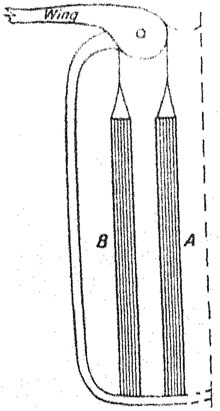
Amongst insects, however, the mechanism of the wing-muscles does definitely separate one small order, viz., the dragon-flies, from all the others. Dragon-flies or their allies are, I believe, geologically the oldest form of insect known, and the action of their wing-muscles is the simplest. It is represented diagrammatically in text-fig. 3.

Each of the group of muscles which act on the wing is attached at its lower end to processes of the thorax, and is capped by a chitinous cone, rather like an extinguisher, terminating in a fine ligament. These ligaments lead respectively to points on either side of the wing-joint; thus the contraction of one set of muscles (represented by A in the figure) raises the wing, while the other group, B, depresses it.

In all other Orders of flying insects the arrangements are much more complex. The muscles are never directly attached to the wings, but to various portions of the thorax, quite distant from the wing-joint, and deformation of the thorax caused by their contraction acts indirectly on the wings. It would require more elaborate figures than can be given here to make this action clear, but text-figs. 4, 5, and 6 indicate roughly the sections (in the three principal planes) of the thorax and groups of muscles. The dotted lines in 5 and 6 show the kind of deformation produced by the more or less horizontal and vertical groups.

The question arises as to why has this complicated and indirect method prevailed.

Text-figure 3.



Diagrammatic half cross-section.

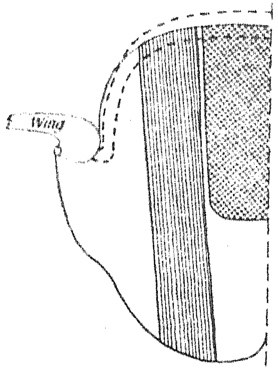
Action of wing-muscles of Dragon-flies.

If the problem were set of designing a mechanism for flapping wings the dragon-flies solution would certainly be the first to suggest itself; yet it evidently must have some disadvantages since it has not been generally adopted.

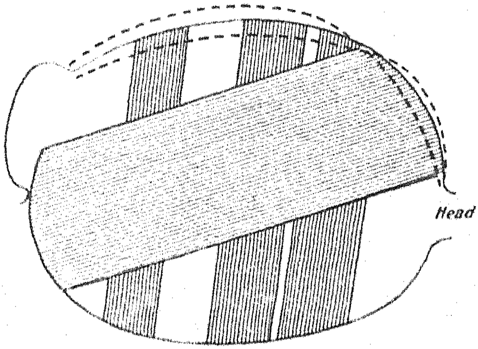
Amongst many other curious mechanical devices found in insects the folding of the wings is worth attention. The folding here referred to is not the mere alteration of the attitude of the wings at rest and in flight; but an actual folding of the wing itself, after the manner of a fan. Here, again, more elaborate figures than can be given in this place would be required to show the complexity which is found in some of these folded wings.

The simplest is that used by some of the Hymenoptera, where a single longitudinal fold is formed from the base to near the tip. This, while not altering the length of the wing in repose, diminishes its width. In the majority of flying beetles the length of the wing in the folded position is reduced. This is effected by a joint on the leading edge of the wing from which the nervures on the folding part of the wing-membrane radiate. The wing so

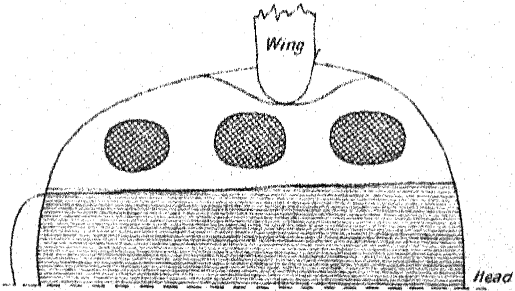
Text-figure 4.



Text-figure 5.



Text-figure 6.



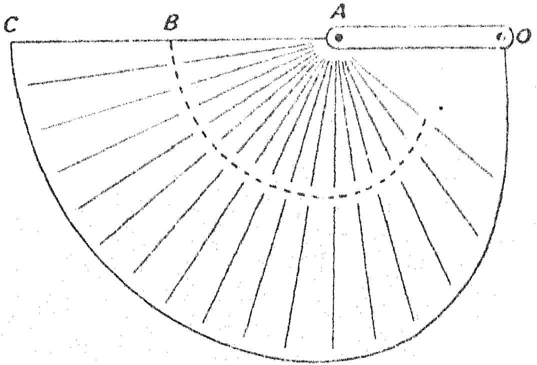
Typical arrangement of flight-muscles in other Orders:—
(4) half cross-section of thorax; (5) longitudinal section of thorax;
(6) half plan-section of thorax.

folded can then be completely covered by the elytra. The muscle operating the folding part is contained in an enlarged nervure at the base of the wing.

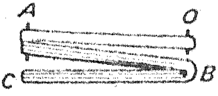
Some of the beetles with short elytra and some of the Orthoptera (notably earwigs) have two such joints on the length of the wing so that the latter when folded is only one third as long as when extended.

The folds in such wings are extremely complex and can be more or less represented by a fan at the end of a handle, half the length of the fan itself. The wing-membrane must be supposed to be continued from the fan proper to the base of handle. Each rib of the fan is jointed at its half length, but the axis of these joints is in the plane of the fan and at right angles to the rib. See text-fig. 6.

Text-figure 7.



Text-figure 8.



Text-figs. 7 & 8.—To illustrate the triple folding of wing of Earwig. The letters mark identical points in the expanded and folded conditions.

In folding, the fan is first shut and the leading edge turned through nearly 180°, but before this motion is completed the half-way joint comes into action so that the outer edge of the membrane is now under the joint of the fan. See text-fig. 7.

In the case of earwigs, at any rate of the species found in England, it seems more than doubtful whether the wings are ever used. The thorax only contains traces of flight muscles, and I have not been able to distinguish any folding muscles in the wings themselves.

The ancestors of the present species probably had working wings which for some reason have now fallen into disuse.

11. On some Equatorial and other Species and Genera of African Ichneumoninæ contained in the Collection of the British Museum. By Claude Morley, F.E.S., F.Z.S., &c., Framlingham, England.

[Received April 11, 1919: Read June 17, 1919.]

Only a small part of the very numerous specimens now lying idle and neglected in our National Museum is here treated of—in fact, only species referable to the first (Ichneumoninæ) of the five known Subfamilies of Ichneumonidæ have been touched upon, and of that Subfamily no more probably than a tithe. One of the interesting points of the present paper is the discovery in Equatorial Africa of genera, though no new species known hitherto only from Asia; and this goes to strengthen a possible former connection of the two faunas, by way of the Chagos Archipelago and the Seychelle Islands, suggested by me (Trans. Linn. Soc. xv. 2, 1912, p. 170). But, although identical species are captured at Lyndhurst and Simla, none of the African ones to the south of the Sahara—except such stragglers as *Bassus lætatorius*—appear to be quite the same as upon the northern coasts of the Mediterranean; indeed, a few forms, *e. g.*, the genera Magwenga and Skiapus, are exclusively Ethiopian, while the larger Xoridides and Cryptides are among the finest and most beautiful in the world. All, or nearly all, the insects of the present paper are contained in the material collected by S. A. Neave in East Central Africa during recent years; wherever there is reference to other entomologists their names are inserted in full.

Classified Catalogue
of Species and Genera herein described.

ICHNEUMONIDÆ.

Ichneumoninæ.

Joppides.

Epijoppa *Mort.*
1. verecunda *Tosq.*
2. fumosa *Mort.*
3. pygidifer, sp. n.
4. dimidiata *Mort.*
5. corrugata *Tosq.*
6. cucolea *Mort.*
7. carinifer, sp. n.
8. triangulifer, sp. n.
9. variabilis *Mort.*
10. pilosa *Cam.*
11. striatifrons, sp. n.
12. rubricata *Mort.*

Trogus *Panz.*
1. gryps, sp. n.

Catadelphus *Wesm.*
1. anceyi *Berth.*
2. nigrocyaneus *Tosq.*
3. rubricaput, sp. n.

Erythrojoppa *Cam.*
1. rufipedalis, sp. n.
2. nigripedalis, sp. n.

Leptophatnus *Cam.*
1. ruficeps *Cam.*

Ctenochares *Först.*
1. blandita *Tosq.*
2. testacea *Szépl.*
3. microcephala, sp. n.
4. gracilentor, sp. n.

Ischnojoppa *Kriech.*
1. luteator *Fab.*

Xanthojoppa *Cam.*
1. lutea *Cam.*
2. debilitor, sp. n.
3. rotundator, sp. n.
4. truncator, sp. n.
5. inermis *Mort.*
6. explanator, sp. n.
7. gracilator, sp. n.
8. striator, sp. n.
9. bipapillator, sp. n.
10. collifer, sp. n.
11. cothurnator, sp. n.
12. geminator, sp. n.
13. areolator, sp. n.

Hoplismenus *Grav.*
1. fulvator, sp. n.
2. cibdelus *Tosq.*

Corymbichneumon, g. n.
1. carinifer, sp. n.

AGLAOJOPPA *Cam.*
1. johannis *Cam.*
2. glabrinotor, sp. n.
3. comptulus *Tosq.*

CŒLICHNEUMON *Thoms.*
1. scopulifer, sp. n.
2. cornellifer, sp. n.
3. maculiscutis *Cam.*
4. natalensis *Cam.*
5. sublunifer, sp. n.
6. geminifer, sp. n.
7. testaceus *Cam.*
8. globulifer, sp. n.
9. sulcifer, sp. n.
10. thyridifer, sp. n.
11. striatifer, sp. n.

Ichneumonides.

Oxypygini.

LAGENESTA *Cam.*
1. sinifer, sp. n.
2. duplicator, sp. n.
3. triplicator, sp. n.
4. triangulifer, sp. n.
(monitor, sp. n.)

MELANICHNEUMON *Thoms.*
1. carinifer, sp. n.
2. melanopterus, sp. n.
3. glaucopterus, sp. n.

LEPTOTHECUS *Cam.*
1. alutacefer, sp. n.
2. punctifer, sp. n.
3. mesonotifer, sp. n.

STENICHNEUMON, *Thoms.*
1. ochraceator, sp. n.

CRATICHNEUMON *Thoms.*
1. testaceocolor, sp. n.

BARICHNEUMON *Thoms.*
1. concinnator, sp. n.
2. incubitor *Linn.*
3. planinotum, sp. n.
4. sexalbatus *Wesm.*
5. fossifer, sp. n.
6. mundatus *Tosq.*

ICHNEUMON *Linn.*
1. rubrornatus *Cam.*

CHASMIAS *Ashm.*
1. glaucopterus *Mort.*
2. ruficaudator, sp. n.

Amblypygini.

AMBLYTELES *Wesm.*
1. spilopterus, sp. n.
2. auricomus, sp. n.
3. fulvocaudatus Tosq.
4. negatorius *Fab.*
5. maculicaudis *Cam.*
6. testaceator, sp. n.

SPILICHNEUMON *Thoms.*
1. didymatus, sp. n.
2. unipunctor, sp. n.
3. triangulator, sp. n.

XENOJOPPA *Cam.*
1. fossifrons, sp. n.
(kali, sp. n.)

CTENICHNEUMON *Thoms.*
1. castanopygus, sp. n.

Heresiarchini.

MAGWENGA, gen. nov.
1. maculipennis, sp. n.

MIOJOPPA *Cam.*
1. quadrilineola, sp. n.

Listrodromini.

NEOTYPUS *Först.*
1. obscurator, sp. n.

Platylabini.

PLATYLABUS *Wesm.*
1. atricinctus, sp. n.
2. mediorufus, sp. n.
3. ceta *Mort.*
4. vallatus *Mort.*

Phæogenini.

BENECLES *Cam.*
1. dimidiatus, sp. n.
2. politanus, sp. n.

ICHNEUMONIDÆ.

ICHNEUMONINÆ.

JOPPIDES.

EPIJOPPA.

Morley, Revis. Ichneum. iv. 1915, p. 49.

Tosquinet in 1896 described two species of the Fabrician genus *Joppa* from Africa; and these, upon examination, I found to differ to such an extent from the more typical Neotropical forms of that genus that I erected a new one for them under the above name, and in it added six other kinds that appeared then to be undescribed. One or two of the characters at that time ascribed to the group must be deleted in order that it may include other species, which, while agreeing in all the more salient features, differ herein: the scutellum, though sufficiently convex, is not invariably subpyramidal nor always deeply punctate, and in one of the following new kinds the peculiarly glabrous and glittering metanotal areola is replaced by one of the more common dull and rectangular form. As a whole, the genus is remarkable in its brilliant metallic coloration and the rugosity of the surface, often combined with totally nigrescent wings. One specimen I have seen was labelled "Mackayella rufa. Type"; but this appears to be a MS. name. The known species are as follows:

Table of Species.

(10)	1.	Anterior wings more or less broadly infumate.	
(7)	2.	Infumation of wings dense throughout; head red.	
(6)	3.	Abdomen fusiform; hypopygium not covering terebral base.	
(5)	4.	Mesonotum and scutellum red; hind tarsi normal.	1. *verecunda* Tosq.
(4)	5.	Mesonotum red, scutellum blue-black; tarsi incrassate	2. *fumosa* Morl.
(3)	6.	Abdomen subcylindrical: hypopygium covering terebral base	3. *pygidifer* Morl.
(2)	7.	Infumation of wings extending from centre only; head not red.	
(9)	8.	Facial orbits and anus not pale; hind femora bright red	4. *dimidiata* Morl.
(8)	9.	Facial orbits and anus pale; hind legs entirely black	5. *corrugata* Tosq.
(1)	10.	Anterior wings hyaline or subhyaline throughout.	
(12)	11.	Mesonotum metallic blue; wings subhyaline	6. *caerulea* Morl.
(11)	12.	Mesonotum entirely rufescent; wings hyaline.	
(22)	13.	Antennæ and legs mainly black; mesonotum dark red; anus white.	
(19)	14.	Inner orbits more or less broadly, and anterior coxæ, white.	
(18)	15.	Base of metanotum longitudinally striate on either side.	
(17)	16.	Scutellum convex, shining, punctate; mesonotum simple	7. *carinifer* Morl.
(16)	17.	Scutellum pyramidal, dull, rugose; mesonotum bituberculate	8. *triangulifer* Morl.
(15)	18.	Base of metanotum not at all longitudinally striate	9. *variabilis* Morl.
(14)	19.	Inner orbits and anterior coxæ immaculate.	
(21)	20.	Metanotal areola nitidulous; second segment not pale	10. *pilosa* Cam.
(20)	21.	Metanotal areola dull; second segment apically white	11. *striatifrons* Morl.
(13)	22.	Antennæ, legs, and mesothorax brick-red; abdomen unicolorous	12. *rubricata* Morl.

1. VERECUNDA Tosq.

This, the type of the genus, was described by Tosquinet (Mém. Soc. Ent. Belg. v. 1896, p. 101) from the Cape; it appears to be not uncommon, and I have already recorded it from Natal, Rhodesia, British East Africa, Uganda, and Nyasaland. Additional material is from Mlanje in Nyasaland at 2300 feet on September 5, 1913, and the valley of the Kola River, near E. Mount, Chiperone, in Portuguese East Africa, at 1500 to 2000 feet on 3rd April, 1913.

2. FUMOSA Morl.

This species usually has the pronotum and propleuræ red, but the latter is occasionally, like the prosternum, black-blue; its anal white markings are not infrequently obsolete. It is apparently somewhat local in Central Africa; I have recently seen females taken at Mlanje in Nyasaland on 5th and 25th September and 7th November, 1913, by Neave; and at Salisbury in Mashonaland in September 1913, as well as at 5000 feet there during June 1900, by Marshall.—The var. *apicalis* certainly does not merit specific rank, for I have seen a ♀ of intermediate form between the typical one and this variety, which, while showing the apically clear wings of the latter, bears no white markings at all, and, moreover, has the mesonotum and part of mesopleuræ of the dull ferruginous coloration found in *E. triangulifer*, though the abdomen is of normal breadth and much broader than in that species. It was taken at Mlanje in Nyasaland, between September and February, 1914, by J. B. Davey.

3. PYGIDIFER, sp. n.

A stout and somewhat large, bright blue species with the head, pronotum, and propleuræ red; centre of the long flagellum broadly, second segmental plica and the anus from middle of the sixth segment, white; and the mandibles and remainder of flagellum black. Abdomen gravid with the second and third segments longer than broad, and the hypopygium covering base of terebra. Length, 23 mm. ♀ only.—The resemblance of this species to *E. fumosa* is remarkable in the structure and coloration of the head, thorax, legs, and wings, of which the last are somewhat more ample though equally infumate; but the subcylindrical abdomen is utterly different in shape and anal structure. The second segment is distinctly and the third slightly longer than broad, with the former deeply emarginate in the centre of its apex and the latter more broadly on either side of its base; apex of second and whole of the following segments glabrous and strongly nitidulous, as also is the convex venter; hypopygium large, apically simply rounded and covering base of the almost concealed terebra. So extraordinary is this structure that a new genus would be requisite for the present species were it not that both oxypygous and amblypygous forms occur in the allied genus *Protichneumon*.—The type was captured at Entebbe in Uganda during August, 1911, by C. C. Gowdey.

7. CARINIFER, sp. n.

A dull ferruginous and coarsely sculptured species with the palpi, mandibular base, frontal orbits, flagellar band, anus from fifth segment, ventral plica and more or less of the anterior with apex of the hind coxæ beneath, and inner side of anterior femora, white; mandibular apex, flagellum, apex of prosternum and base of mesosternum, and remainder of anus from base of fourth segment, hind trochanters with their tarsi and more or less of their tibiæ, black; wings hyaline or slightly flavescent, with stigma black. Length, 12–14 mm. ♀ only.—Known by its distinctive coloration, the but slightly convex and glabrous scutellum which bears a few scattered punctures, the simple mesonotum, by the longitudinal striation at metanotal base, and especially by the shining longitudinal carina on centre of both mesonotum and second segment.—Probably not rare: Mlanje at 2300 feet, on 13th June and 8th October, 1913, in Nyasaland; on the S.E. slopes of Mount Kenya at 6–7000 feet, between 3rd and 12th February, 1911, in British East Africa; at Western Ankole at 4500 to 5000 feet in mid-October, 1911 (*Neave*), and an unlocalised specimen (ex coll. Cameron) from Uganda.

8. TRIANGULIFER, sp. n.

A dull ferruginous and coarsely sculptured species with flagellar band and anus from fifth segment alone, white; mandibular apex, flagellum, whole sternum indefinitely, a discal mark at base of fifth segment and nearly the whole legs, black; wings hyaline with stigma black. Length, 15–17 mm. ♂ ♀.—Much narrower than *E. fumosa* and constantly larger than *E. carinifer*, from the latter of which it differs in little but its less profuse markings, subpyramidal and closely rugose scutellum, and in having the mesonotum slightly elevated tuberculiformly on either side of its apex, the centre of which is triangularly depressed. The typical ♂ has the facial orbits broadly but not the frontal, base of mandibles and of palpi, the anterior coxæ beneath and their femora internally, stramineous; flagellum immaculate black.—All the specimens I have seen were captured by Neave at Mlanje in Nyasaland, at about 2300 feet, during the first half of June and early in September, 1913.

10. PILOSA Cam.

Henicophatnus pilosus Cam. Ann. S. Afr. Mus. v. 1906, p. 166, ♀; *Epijoppa nigricoxata*, Morl. Rev. Ichn. iv. 1915, p. 53, ♂ ♀.

I have examined Cameron's type, from the district of King William's Town, in the Cape Town Museum.

11. STRIATIFRONS, sp. n.

A short and somewhat stout species with the scape, head, except the black mouth and clypeal apex, pro- and mesothorax with scutellum, crimson; metathorax and basal segment bright blue, remainder of abdomen violaceous with anus, apex of second segment both above and below, and apex of the first below only, pale stramineous; legs entirely and flagellum, except its central stramineous band, black; metathorax coriaceous, with fine carinæ and the areola not more shining. Length, 13 mm. ♀ only.—Similar in size and sculpture to *E. nigricoxata* Morl. (Revis. Ichn. iv. 1915, p. 53), but with the frons, which is utterly glabrous in *E. verecunda*, stoutly trans-striate throughout, the rugose scutellum but simply convex, the metanotal areola half as long again as broad, rectangular, flat and not shining, and the second segment like the anus apically white.—Entebbe in Uganda during the first half of September, 1911.

TROGUS.

Panzer, Krit. Revis. ii. 1806, p. 80; Förster, Verh. pr.
Rheinl. xxv. 1868, p. 188.

The *Trogus* group of Joppid genera consists of *Dinotomus*, *Catadelphus*, *Trogus*, and *Automalus*. Dalla Torre's Catalogue of 1902 listed thirty-three species of the main genus, but seven of these belong to *Dinotomus* and one (*teste* Viereck, Proc. U.S. Nation. Mus. xlvi. 1913, p. 369) to *Aglaojoppa*, and a ninth proved to be synonymous; but none of them have hitherto been known from Africa. *Automalus*, with its single palæarctic and single Alaskan species, is equally unknown; but the widespread *Dinotomus lapidator* Fab. extends to Algeria from the north. *Catadelphus* was represented by a couple of kinds, both described in 1896, but not since recorded. In 1844, Wesmael split off *Automalus* from *Trogus* on account of its straight and not centrally angled clypeus, and ten years later he erected *Catadelphus* for the reception of *Ichneumon arrogator*, because its scutellum was simply convex and not pyramidal as in the more typical species. Several of Cameron's Indian Joppides also belong to the present group, but there will at present be need to consider no more than one of them.

*1. GRYPS, sp. n.

An extremely large and stout, blue-black species, with the flagellum except apically and legs except basally, conspicuously pale. Head, thorax, and apical attenuation of flagellum black, with the centrally elevated face and sometimes the temples badious; clypeus apically truncate, labrum strongly exserted. Mesonotum and scutellum very dull and dead black with the base of the former longitudinally impressed, the latter not strongly elevated and laterally carinate only to its centre; metanotum rugose with areola triangular, costulæ strong though irregular, and a basal prominence on either side. Abdomen black or blue-black and smooth with basal segment dull, finely punctate, and centrally bicarinate; terebra stout and hardly exserted. Legs long and stout, bright testaceous with coxæ, trochanters (front ones badious) and onychii alone black. Wings large and ample, strongly and evenly fumate, with blue reflection; discoidal cell narrow and parallel-sided; nervelet small; areolet higher than broad, elongate-triangular and coalescent above. Length, 26 mm.; exp. al. 48 mm. ♀ only.—Larger than *Catadelphus nigrocyaneus* with dull mesonotum, no white flagellar band, &c.; most closely allied to the Sonoran *T. atrocæruleus* Cresson.—Gowdey found the type at Entebbe in Uganda on 17th June, 1913; and Neave took another female, with entirely black (probably owing to grease) abdomen, at Mlanje in Nyasaland, on 8th February, 1913.

CATADELPHUS.

Wesmael, Bull. Acad. Sc. Belg., Annexe, 1854, p. 134.

Not more than half a dozen species are yet described, but these are distributed over southern Europe to the Red Sea, the United States, Central America, and the northern half of Africa.

Table of African Species.

(2) 1. Alar areolet pentagonal; legs black, tibiæ and tarsi red .... 1. *anceyi* Berth.
(1) 2. Alar areolet triangular; hind femora and tibiæ black or red.
(4) 3. Head quadrate and black; hind femora and tibiæ fulvous .... 2. *nigrocyaneus* Tosq.
(3) 4. Head transverse and red; hind femora and tibiæ black .... 3. *rubricaput* Morl.

3. RUBRICAPUT, sp. n.

A large, blue-back insect with the anus and centre of flagellum white-marked. Head indefinitely rufescent, small and constricted behind the prominent eyes; face closely punctate, transverse and not higher than the sparsely punctate and apically truncate clypeus; mandibles aciculate-punctate, with their margins smooth and teeth black; frons centrally sulcate and somewhat elevated. Antennæ black and rather strongly inflated beyond the central white band which is broad, but incomplete below. Thorax black and closely punctate; mesonotum, especially laterally, smoother with elongate and subparallel notauli; metanotal carinæ entire, areola narrow and obsoletely discreted from the basal area, apically elevated and emitting costulæ from its centre; petiolar and dentiparal area obliquely substriate; spiracles elongate, apophyses wanting. Scutellum black, convex and smooth, with large and sparse puncturation; its lateral carinæ vallate and extending to near apex. Abdomen deplanate, elongate fusiform and blue with purpurascent reflection; postpetiole shagreened and centrally aciculate, second and third segments very finely punctate and dull with gastrocœli of former deeply impressed, though hardly as broad as the striate and transimpressed intervening space; remainder nitidulous with disc of seventh, and apex of sixth discally, flavous; venter plicate throughout, with terebra slightly exserted and spicula red. Legs slender and black (femora et tibiæ anticorum, articulis 3–5 tarsorum posticorum desunt). Wings evenly nigrescent throughout, with brilliant blue iridescence; stigma, nervures, and the punctate tegulæ, black; areolet triangular, subcoalescent above; basal nervure continuous through median, nervelet obsolete.

Length, 23 mm. ♀ only.—Very like *Catadelphus nigrocyaneus* Tosq., though with the head not quadrate and entirely red, the anus white, &c.—The type occurred to Delmé-Radcliffe at Msozi in Uganda during February 1903.

ERYTHROJOPPA.

Cameron, Ann. Nat. Hist. ix. 1902, p. 146.

Head with the labrum exserted, and clypeus apically truncate; base of flagellum usually broadly rufescent, its centre in ♀ somewhat strongly dilated. Base of metanotum deeply discreted and vertically elevated; areola small and tuberculiform, not laterally carinate nor depressed; areæ entire; petiolar area basally carinate, narrow and a little explanate throughout; apophyses wanting. Scutellum pyramidal and in ♂ discally acute; higher than mesonotum and laterally carinate at least basally, with its basal declivity in ♂ subvertical and the apical oblique. Abdomen elongate and usually narrow, about double length of thorax; postpetiole distinct; discal striæ of second segment centrally elevated; venter with segments two to four plicate and the apical obtuse, nearly as long as penultimate. Legs elongate, with tarsi spinulose; hind femora not extending to apex of third segment. Areolet broadly triangular, coalescent above; nervelet often distinct; recurrent nervure centrally, and radius basally, sinuate; basal nervure subcontinuous through median.—The great majority of Peter Cameron's genera are unintelligible without reference to the types; those of *Erythrojoppa* are in the British Museum, and his four Indian species seem to represent the opposite sexes of but two. The following insects are sufficiently homogeneous, though the abdomen is a good deal broader and more deplanate than in those formerly described.

1. RUFIPEDALIS, sp. n.

Dull pale ferruginous, with the abdomen blue and wings evenly nigrescent; base of propleuræ black-marked. Head posteriorly buccate and nearly as broad as the often testaceous eyes; ocellar region circumsulcate; frons concave and radiately striate from scrobes; face closely and confluently punctate, centrally and laterally elevated; clypeus large, distinctly and evenly punctate, laterally elevated, with its apex truncate and stoutly margined. Antennæ subdilated beyond centre and apically attenuate; fourteen basal flagellar joints bright testaceous and remainder black. Thorax robust and stoutly shagreened; notauli short and distinct, sternauli wanting; speculum glabrous and impressed, finely striate below; metathorax evenly coriaceous with complete areæ and strong carinæ; petiolar area very narrow, trans-striate and extending nearly to base; spiracles linear, apophyses wanting. Scutellum strongly convex and almost pyramidal, discally obtuse, shining and pilose with a few sparse and fine punctures.

Abdomen elongate-fusiform, deplanate, bright metallic blue, with petiole alone (though to a variable extent) rufescent; postpetiole broader than long, finely shagreened with deep apical and lateral punctures; second and third segments closely punctate, former not basally striate, its gastrocœli large and transverse; venter plicate throughout; hypopygium remote from the subexserted, black terebra. Legs stout and somewhat short, brick-red with only the onyches black; hind coxæ with stout scopulæ. Wings ample and evenly nigrescent, with stigma black; areolet triangular, coalescent above; nervelet obsolete. Length, 20–22 mm. ♀ only.—Apparently common in Central East Africa; many taken at Mlanje during May, June, September, and December, 1913; in the Ruo Valley at 2000 feet in December 1913; and to the S.W. of Lake Chilwa, during January 1914, in Nyasaland; as well as at Masongaleni at 3000 ft. in March 1911, in British East Africa (*Neave*); and near Chirinda Forest in Gaza Land, during March 1907 (*Marshall*).

2. NIGRIPEDALIS, sp. n.

Dull, pale ferruginous with the abdomen blue and wings evenly nigrescent; base of mesopleuræ sometimes black-marked. Length, 19–21 mm. ♂ ♀.—This species is certainly distinct from the last, yet the ♀ differs solely in having the hind legs (except usually their trochanters and disc of coxæ) and the intermediate tarsi, black; the flagellum immaculate black and the scutellum pyramidal with its disc acute. The ♂ agrees therewith, but the scutellar disc is subspinately produced.—Entebbe early in September 1911, and on W. shore of the Victoria Nyanza at Buddu at 3700 feet in September 1911, in Uganda; and at Mlanje, during the first half of June 1913, in Nyasaland.

LEPTOPHATNUS.

Cameron, Ann. S. African Museum, v. 1906, p. 165.

The deeply impressed basal metanotal sulcus places this genus incontrovertibly in the Joppides.

1. RUFICEPS Cam.

This striking species was originally described from Cape Colony; but it has a wide range. I have recently examined examples of both sexes (Cameron knew only the ♀, loc. cit., and I brought forward the ♂ in the Annals of the S. Afr. Mus. 1917) from Barberton in the Transvaal, where P. Rendall found it about 1890 (ex coll. Distant); from Mlanje on 25th February, 1913, in Nyasaland; from the Siroko River near the west foot of Mount Elgon at 3600 feet in mid-August, 1911; on the west shore of the Victoria Nyanza at 3700 feet near Buddu during the following September; on the Semliki Plains near the south shore of Lake Albert at 2200 feet at the end of November, 1911; and between Jinja and Busia in some forest east of Busoga at about 3800 feet at the end of July 1911, in Uganda; as well as on the southern slopes of Mount Elgon at some 5500 feet early in the preceding June (*Neave*), in British East Africa.

CTENOCHARES.

Förster, Verh. pr. Rheinl. xxv. 1868, p. 191.

The limits of this genus are, owing to the paucity of its original description, at present somewhat too elastic; but there can, I think, be little doubt that the two new species here brought forward are at least more closely allied therewith than any other. Five kinds belonging here were known to me in 1915; the late V. Szépligeti described another from East Africa (Bull. Mus. Paris, 1907, p. 137) and four more in the Kilimanjaro Expedition, which was published in 1910; I brought forward another from South Africa in 1916 (Ann. S. Afr. Mus. xv. p. 371), and Matsumura has recorded the genus from the Island of Sachalin (Journ. Coll. Sapporo, iv. 1911, p. 94), off the east Asian coast.

1. BLANDITA Tosq.

W. Haygarth has found this species at Durban in Natal.

2. TESTACEA Szépl.

A common species in South Africa, recently captured by Bell Marley at Stella Bush and Howick in Natal, and P. Rendall met with it at Barberton in the Transvaal (in coll. Distant); but rarer farther north, for Neave could find only a single female, with flavidous scutellum and apically black hind femora, on the S.E. slopes of Mount Kenya at 6000–7000 feet during February 1911, in British East Africa.

3. MICROCEPHALA, sp. n.

A clear testaceous insect, with the face and vertical orbits indefinitely stramineous; flagellum and hind tibiæ black with the 8th to 22nd joints of the former, and base of the latter along with their whole tarsi, white. Anterior tarsi nigrescent. Scutellum dull, apically a little constricted, laterally carinate as far as apex; apophyses small, but distinct; gastrocœli large and not white. Wings flavescent-hyaline with areolet as broad as high, and not coalescent above; stigma ferruginous. Length, 15 mm. ♀ only.—Very like *C. testacea* but with the head smaller, abdomen stouter and immaculate; antennæ longer and very broadly white-banded, stigma darker and the hind legs quite differently coloured, with only the onychii black. [*Obs.* In this unique I have taken the left hind tarsus as normal; curiously, the right one has the apical two-thirds of its basal joint nigrescent.] The typical female was taken in Uganda, Southern Toro, Fort Portal Road, at some 4000 feet, towards the end of October 1911.

4. GRACILENTOR, sp. n.

A slender, testaceous species with the head, antennæ, and anus all white-marked black; hind tarsi nigrescent throughout. Head transverse-oval and posteriorly nearly as broad as the not very prominent eyes; flavous with the occiput, vertex, and frons black; frontal orbits to vertex citrinous; occiput abruptly declivous behind eyes and, like the centrally carinate frons, closely punctate; face and clypeus flat, closely and confluently punctate, not discreted and the latter centrally depressed before its apical margin; labrum exserted, mandibles very slender with the teeth piceous. Antennæ filiform and serrate, black with scape and underside of basal half rufescent; flagellar joints 16–23 white; apices desunt. Thorax cylindrical and substramineous with no notauli, apophyses nor areæ; areola represented by two slight longitudinal carinæ. Scutellum dull, but slightly convex, carinate to apex. Abdomen sublinear, much longer than head and thorax; basal segment linear with the obsoletely punctate-aciculate postpetiole hardly broader; gastrocœli very small; anus black from near base of the fifth segment with the seventh, apex of sixth and the stout valvulæ, white. Legs slender and somewhat elongate. Wings narrow, flavescent-hyaline; stigma luteous; areola pentagonal, broad above; radial cell elongate and narrow. Length, 14–15 mm. ♂ only.—The outline of the abdomen is curiously like that of *Mesoleptus* males.—Found at Howick in Natal about 1904, by J. P. Cregoe.

ISCHNOJOPPA.

Kreichbaumer, Entom. Nachr. xxiv. 1898, p. 82.

This distinct genus needs more revision than I am at present able to effect. It was erected for the reception of a species of Joppid with elongate metapleural spiracles, occurring in both India and Senegal; and I have shown that Chinese, Bornean, and Australian examples are not structurally distinct (Revis. Ichn. iv. 1915, p. 97). Dr. A. Roman finds that *Ischnus melanopygus* Holmgren and its variety belong here (Entom. Tidskr. xxxi. 1910, p. 172); and it seems nearly certain that the two kinds described under *Ischnus* by Tosquinet in 1896 must also be included, on account of their elongate thoracic spiracles—thus Africa will be left with but a single *Ischnus*-species (*I. trochanteratus* Burgst, Tijds. v. Entom. lv. 1912, p. 267; Tunisian Hym. 1913, p. 15, ♀). Szépligeti brought forward two new species of *Ischnojoppa* from Kilmanjaro in 1910, and two more from Java (Leiden Mus. Notes, xxix. p. 235) in 1908: also, I have added a couple (Ann. S. Afr. Mus. 1916–17), giving the total of nine known kinds, of which seven are African. Some synonymy may be expected.

1. LUTEATOR Fab.

Ichneumon luteator Fabricius, Ent. Syst. Suppl. 1798, p. 222; *Bodargus rufus* Cameron, Journ. Str. Br. R. Asiatic Soc. xxvii. 1902, p. 53.

In Africa this species is already recorded from Sierra Leone, Congo, Uganda, Nyasaland, British East Africa, German (olim !) East Africa, Rhodesia, and Zululand. Additional material is from Kayena in Cape Colony during October 1916 (L. Péringuey); the east slopes of the Aberdare Mountains at 7000 to 8500 feet in British East Africa at the end of February 1911; and a male (with the vertex black and external radius remarkably straight) from Western Busoga, between Kakindu and the S.E. shore of Lake Kioga at 3500 feet on 22nd of the following August, in Uganda.

Neave also took a couple of males, which I shall here merely term VAR. *unicolor*, nov., though they are pretty certainly of specific rank, for their coloration is testaceous with nothing but flagellum (excepting the normal white band) and mandibular teeth black; further, the abdomen is a little rounded laterally, a good deal less parallel-sided than the typical form, the external radius is nearly straight and the areolet much narrower, nearly coalescent above. These occurred near Kampala on the Kampala-Jinja Road, which is partly forest, during July 1913; and in the Durru Forest, Toro, at the end of October 1911, both at 4000 feet, in Uganda. With them, Neave sent home a single female, which may or may not belong here, for (though the radius is sinuate and abdomen linear) only the mandibular teeth, part of flagellum, and the anus from base of fifth segment, are black. This was found on the S.E. slopes of Mount Kenya early in February 1911, at fully 6000 feet, in British East Africa.

XANTHOJOPPA.

Zanthojoppa Cameron, Ann. Nat. Hist. vii. 1901, p. 378.

This genus of testaceous insects was erected for the reception of a single Khasian species, and its author added five more in the same Magazine during 1903 and 1907, all from eastern India. In 1906 Cameron erected another name for a South African species (ANISOJOPPA, Ann. S. Afr. Mus. v. p. 168), which differs so little that I ventured to synonymise them, when bringing forward a new kind (*X. inermis* Morley, *lib. cit.* xv. p. 358) in 1916 from Cape Colony. I now find the genus to be well represented in Central Africa by numerous specimens and a dozen somewhat closely allied species, which may be recognised by:—Head somewhat small, not broader than thorax and never buccate; posteriorly narrower than the internally entire eyes; ocelli always, but their intervening space rarely, black; clypeus neither short nor discreted from the deplanate face, apically subtruncate; cheeks elongate. Antennæ nearly always white-banded in both sexes, long and slender, of ♂ setaceous and distinctly serrate, of ♀ but slightly dilated centrally and apically acuminate. Notauli wanting, mesonotum always shagreened and dull; metanotum also usually shagreened, areæ wanting with areola at most indicated; costulæ and spiracular carina always wanting. Scutellum convex, rarely pyramidal, always laterally and usually also apically carinate. Abdomen elongate and in both sexes subcylindrical, dull and always immaculate testaceous, with hypopygium remote from terebral base. Legs slender and longer than in the Asiatic species, testaceous with the hind ones rarely black- and white-marked; tarsal claws simple. Wings ample and always flavescent, with stigma testaceous.—Superficially this genus is similar, especially in the shape of the capital vertex, to testaceous species of *Hoplismenus*, from which the shagreened exoskeleton, lack of conspicuous apophyses, paucity of metanotal carinæ, and very much duller body sufficiently separate it, though the scutellar structure is alike.

Table of African Species.

(22) 1. Flagellum white-banded in both sexes; metanotal areola obsolete or wanting.

(21) 2. Head not abruptly declivous posteriorly, temples distinct; tarsi not white.

(10) 3. Apex of scutellum depressed and not at all carinate.

(5) 4. Areola nearly circular; hind tarsi and tibiæ both black .... 1. *lutea* Cam.

(4) 5. Areola rectangular or wanting; at most hind tarsi infuscate towards apices.

(7) 6. Smaller; stramineous; scutellum finely carinate laterally .... 2. *debilitor* Morl.

(6) 7. Larger; testaceous; scutellum strongly carinate laterally.

(9) 8. Scutellum apically rounded; postpetiole abruptly explanate .... 3. *rotundator* Morl.

(8) 9. Scutellum apically truncate; postpetiole gradually explanate .... 4. *truncator* Morl.

(3) 10. Apex of scutellum elevated and carinate throughout.

(20) 11. Face regularly punctate; scutellum not longer than basally broad; hind tarsi mainly testaceous.

(19) 12. Mesonotum apically simple; postpetiole not stout.

(14) 13. Face distinctly punctate; metanotum dull and not striate; its transcarina wanting .... 5. *inermis* Morl.

(13) 14. Face obsoletely punctate; metanotum striate and not dull, its transcarina distinct.

(18) 15. Frontal orbits not pale; metanotal trans-striation weak.

(17) 16. Postpetiole subcircular and abruptly explanate ... 6. *explanator* Morl.

(16) 17. Postpetiole slender and gradually explanate ...... 7. *gracilator* Morl.

(15) 18. Frontal orbits stramineous; metanotum strongly striate .... 8. *striator* Morl.

(12) 19. Mesonotum apically bituberculate; postpetiole stout .... 9. *bipapillator* Morl.

(11) 20. Face irregularly punctate; scutellum longer than basally broad; hind tarsi entirely black .... 10. *collifer* Morl.
(2) 21. Head abruptly declivous behind eyes, temples obsolete; hind tarsi white-banded .... 11. *cothurnator* Morl.
(1) 22. Flagellum not white-banded; metanotal areola well defined.
(24) 23. Metanotum laterally black; areola dull; legs all testaceous .... 12. *geminator* Morl.
(23) 24. Metanotum immaculate; areola shining; hind tarsi black .... 13. *areolator* Morl.

1. LUTEA Cam.

Only known from the south of the Continent, in the Cape and Natal; and apparently not extending far north, since I have seen none of the present genus with entirely black hind tibiæ from Rhodesia, &c. Cameron's generic diagnosis is drawn entirely from the ♀, as I have pointed out (Ann. S. Afr. Mus. xvii. 1917, p. 195). I possess the species from Zululand.

2. DEBILITIOR, sp. n.

A small, pale, debilitant form, differing from the remainder of the genus in its paler coloration, proportionately shorter antennæ of but 8 mm., the peculiarly small head with black ocellar region, the shorter legs and, especially, in the weak lateral scutellar carinæ, which do not extend to the apex. Length, 10 mm. ♂ only.—The unique type was captured at Howick in Natal by J. P. Cregoe, and presented to the British Museum in 1904.

3. ROTUNDATOR, sp. n.

This is the first of a series of extremely closely allied species, which I find to differ *inter se* in nothing but the facial punctuation, mesonotal colour and apical contour, mesonotal and scutellar and postpetiolar structure, as well as occasionally the colour of the hind legs.—The present insect has the face obsoletely punctate; mesonotum apically simple, with its sides rarely infuscate; metanotum dull and not striate, its transcarina wanting, and areola both rectangular and obsolete; scutellum longer than basally broad with its apex depressed, rounded, and not carinate; postpetiole laterally curved and abruptly explanate basally; legs testaceous, with the hind tarsi infuscate towards their apices. Length, 12–15 mm. ♂ ♀.—It is recognised by the scutellar and postpetiolar structure, and by having the radial nervure distinctly more reflexed than that of its congeners. Quite the commonest species of the genus in British East Africa, where S. A. Neave found males between 7000 and 8500 feet on the east slopes of the Aberdare Mountains towards the end of February 1911; at 5000 to 6000 feet on the south slopes of Mount Elgon in the middle of June; and 500 feet higher among some forest on the Nandi Plateau at the end of the preceding May. But the majority are from Uganda, where C. C. Gowdey took it in the Mabira Forest at Chagwe in the middle of July 1911;

Neave in the Durro Forest at Toro, on Mount Kokanjero to the S.W. of Elgon, at Mbarara in southern Toro, the Bugoma Forest at Unyoro, and in northern Buddu at altitudes ranging from 3500 to 4500 feet during July and October.

4. TRUNCATOR, sp. n.

Face obsoletely punctate; mesonotum apically simple; metanotum dull and not striate, with both areola and transcarina wanting; scutellum not longer than basally broad, apically depressed and there abruptly truncate though not carinate; postpetiole slender and gradually dilated; legs testaceous, with hind tarsi infuscate towards their apices. Length, 12–14 mm. ♂ ♀. The only species with apex of scutellum truncate.—I have seen but a single pair, of which the male is from the Mabira Forest by Chagwe in July, and the female from Mbarara in southern Toro during October, both at about 3800 feet in Uganda.

5. INERMIS Morl.

Face evenly punctate; mesonotum apically simple; metanotum dull and not striate, areola rectangular and obsolete, transcarina wanting; scutellum not longer than basally broad, apically elevated and carinate throughout; postpetiole slender and gradually dilated; legs testaceous, hind tarsi infuscate towards their apices. Length, 12–14 mm. ♂ ♀.—This is the first of a homogeneous group of species with the scutellum itself somewhat flat, though the stout carina, which entirely surrounds its apex, is distinctly elevated and conspicuous; from its allies, the rectangular and dull areola will distinguish it.—It was first described by me in the female sex from Cape Colony, whence it appears to extend as far as Uganda and British East Africa, in both of which its range is co-extensive with that of *X. rotundator*; I have seen ten examples from the Mabira Forest, the Budongo Forest, near Unyoro, Entebbe, Ilala in the Maramas District at 4500 feet, and from the S.E. slopes of Mount Kenya between 6000 and 7000 feet during March, June, July, February, and December, 1911 to 1914.

6. EXPLANATOR, sp. n.

Face obsoletely punctate; mesonotum apically simple; metanotum shining and trans-striate, with both areola and transcarina wanting; scutellum not longer than basally broad, its apex elevated and carinate throughout; postpetiole subcircular and abruptly explanate basally; legs testaceous, with hind tarsi infuscate towards their apices. Length, 14 mm. ♂ only.—Distinct in the finely trans-striate metanotum which it shares with the next species, and unique in the abrupt dilation of the postpetiole.—I have only seen the type of this species, which was captured in the Gold Coast by W. P. Lowe and presented to the British Museum in 1911.

7. GRACILATOR, sp. n.

Face obsoletely punctate; mesonotum apically simple; metanotum striate and not dull, with areola wanting and transcarina distinct though fine; scutellum not longer than basally broad, apically elevated and carinate throughout; postpetiole slender and very gradually explanate towards its apex; legs testaceous, hind tarsi infuscate towards their apices. Length, 12–14 mm. ♂ ♀. Differs from the last species solely in the presence of the apical metanotal transcarina and the very slender postpetiole.—A common species, of which I have seen a dozen examples from the Durro Forest, Mabira Forest, and Buddu on the west shore of the Victoria Nyanza at 3500 to 4500 feet during July, September, and October, in Uganda; and from a few miles east of Mumias in the Maramas District of British East Africa at the latter altitude in the middle of June 1911.

8. STRIATOR, sp. n.

Very closely allied to the next species and differing from it only in its simple mesonotal apex, its flavidous frontal orbits, basally rufescent flagellar disc and somewhat shorter wings; from this and the whole remainder of the genus it differs in having the head fully as broad as the thorax and the metanotum strongly trans-striate from its apical transcarina to base. Length, 15 mm. ♀ only.—The type, which alone I have seen, was captured on 17th February, 1911, by W. A. Lamborn, in Lagos.

9. BIPAPILLATOR, sp. n.

Face evenly punctate; mesonotum apically elevated on either side into an obtuse tubercle; metanotum shining and trans-striate, areola rectangular and obsolete, transcarina distinct; scutellum not longer than basally broad, apically elevated and carinate throughout; postpetiole stout and gradually dilated; legs testaceous, with hind tarsi nigrescent. Length, 15–17 mm. ♂ only. Instantly known in this genus by the apically bituberculate mesonotum; the large size, dark hind tarsi, and laterally somewhat rounded abdomen are also distinctive.—The largest species of the genus and apparently rare in Uganda, whence I have examined four examples, taken by C. C. Gowdey, all at Chagwe in the Mabira Forest between the 17th–20th July, 1911, and on 3rd July, 1913.

10. COLLIFER, sp. nov.

Face irregularly punctate; mesonotum apically simple; metanotum dull and not striate, areola rectangular and obsolete, transcarina wanting; scutellum distinctly a little longer than basally broad, apically elevated and carinate throughout; postpetiole slender and gradually dilated towards apex; legs testaceous, with hind tarsi entirely nigrescent. Length, 15 mm. ♂ ♀.—A very distinct species, differing from all the above in its irregularly punctate face, subvertical first recurrent nervure, and in having the head behind the eyes constricted in a straight line, which renders the eyes peculiarly prominent. Apparently rare and confined to Uganda, whence I have seen both sexes taken in the Mabira Forest at 3500 to 3800 feet during July, and the Budongo Forest at 3400 feet during mid-December 1911, by S. A. Neave; and about Entebbe during the middle of March 1914, by C. C. Gowdey.

11. COTHURNATOR, sp. n.

A testaceous species, with both antennæ and hind legs white-banded black. Instantly recognised from the remainder of the genus by the pure white third and fourth (and in ♂ fifth) joints of the hind tarsi, which are peculiarly slender; the whole thoracic sculpture, including that of the scutellum, is as in *X. inermis*, but the abdomen is more fusiform and less elongate with its disc, especially apically, more finely punctate and almost nitidulous; the capital structure approaches that of *X. collifer*, though the temples here are very much shorter and the occiput falls away immediately behind the black ocellar region. Length, 12 mm. ♂ ♀.—The distribution seems distinct from that of the foregoing species, for those I have examined are from 4500 to 5000 feet at Western Ankole in mid-October 1911; and the Siroko River, near the west foot of Mount Elgon at 3600 feet, during the preceding August; in Uganda.

12. GEMINATOR, sp. n.

This and the following species are so different from all the above in their deeper ferruginous coloration, black antennæ, shorter and stouter legs, in the rather broader temples, much longer upper mandibular tooth and more robust outline, that they will probably not be found congeneric. *X. geminator* is easily recognised by the longitudinal black mark occupying the confluent external and dentiparal metanotal areæ; it is similar to the next species but the legs are testaceous throughout, the metanotal transcarina is strong with well-defined, subcircular and dull areola, and no trace of costulæ. Length, 12–13 mm. ♂ only. Two males were captured on the N.W. and at Buddu on the W. shores of the Victoria Nyanza at about 3700 feet by Neave, in the middle of September 1911.

13. AREOLATOR, sp. n.

A ferruginous species with the legs neither elongate nor slender, upper mandibular tooth long and transcarina of the immaculate metanotum weak; flagellum entirely black, setigerous and somewhat stout. Differing from the last species in the possession of a well-defined elongate and shining areola with some trace of costulæ; and from the remainder of the genus in having the extreme base (only) of the hind tibiæ, along with the whole of their tarsi, dead black. Length, 12–13 mm. ♂ only. Taken with *X. inermis* and *X. rotundator* in the Mabira and Budongo Forests of Uganda at rather more than 3500 feet during July and December.

Hoplismenus.

Gravenhorst, Ichn. Europ. ii. 1829, p. 409; Wesmael,
Nouv. Mém. Ac. Brux. 1844, p. 13.

Head slender, not tumidous, somewhat narrowed behind the eyes and towards the mouth; clypeus large, apically truncate; labrum usually very shortly exserted. Antennæ slender, setaceous; of ♂ subserrate, of ♀ a little dilato-explanate, beyond their centre. Thorax subcylindrical, discally gibbulous; mesonotum somewhat convex, with distinct notauli; metathorax with basal sulcus profound, and the apophyses acute; spiracles linear or elongate-oval. Scutellum strongly elevated, abruptly declivous apically. Abdomen subfusiform; hypopygium not covering base of the distinctly a little exserted terebra. Legs somewhat slender. Wings normal; areolet pentagonal.

The bidentate metathorax, exserted terebra, &c., lend members of this genus decided Cryptid facies; but the males bear only the faintest traces, and the females none at all, of sternauli. To *Platylabus* it also bears a superficial resemblance but may be distinguished therefrom, besides the major points above indicated, by the straight and slender hind tibiæ and by the pentagonal areolet. This genus has been placed by all former authors among the Oxypygini, and so recently as March 1914 Herr Pfankuch told me (*in lit.*): "It is my mind that *Hoplismenus* belongs to the Ichneumonides"; but the conformation of the metathorax and scutellum, as also the flagellar structure, ally it with the Trogoidæ of Förster, and it was there treated of in my 'Ichneumonologia Britannica' in 1903; among the Oxypygini it were certainly aberrant. Perhaps *Acanthojoppa* Cameron (Entom. xxxv. 1902, p. 109) will prove synonymous, in which case thirteen Asiatic species will be added; but the majority of these have the head a great deal larger and more buccate than any *Hoplismenus* of my acquaintance—though that its author was ignorant of the present genus is proved by his inclusion therein of his *H. ceylonicus* (Spolia Zeylanica, iii. 1905, p. 100), which is a *Eupalamus* and the male of his *Melanichneumon kandiensis* (loc. cit. p. 99).

Africa may be considered the home of *Hoplismenus*, since more kinds are known thence than from the remainder of the globe; these include *Ichneumon dentatus* Smith (Trans. Entom. Soc. London, 1874, p. 391, n. 12), as I am able to state from an examination of the Japanese ♀ type. Kriechbaumer described two species from East Africa in 1894; Tosquinet knew eleven in 1896; Pic found another in 1897; while Szépligeti brought forward no fewer than nineteen additional ones in 1910 from

Kilimanjaro, some of which may belong to *Hoplojoppa*, as was indicated by Dr. Roman (Entom. Tidskr. xxxi. p. 169) in 1910.

1. FULVATOR, sp. n.

Pale testaceous with only part of flagellum, apices of mandibles and of hind onyches, black. Head obliquely constricted and narrow behind the very prominent eyes, whence the occiput falls abruptly away; frons obsoletely punctate, trans-substriate before the ocelli and centrally sulcate; face and clypeus nearly stramineous, flat and obsoletely punctate, with apex of latter truncate and only laterally margined; labrum exserted and cheeks long. Flagellum slender and filiform, black with a central white band, its base rufescent and apex attenuate; of ♂ subserrate, of ♀ distinctly a little dilated, beyond centre. Thorax cylindrical; mesonotum dull and shagreened, with slight notauli; metanotum shining and evenly punctate with complete, but fine, areæ; areola subrectangular, half as long again as broad, extending nearly to base, and emitting conspicuous costulæ from its basal third; spiracular areæ trans-striate; apophyses large, vertical and acuminate. Scutellum much higher than metathorax, its disc closely punctate and not strongly elevated, but both laterally and apically stoutly vallate. Abdomen dull; basal segment very slender with the shining and laterally punctate postpetiole very little explanate; gastrocœli wanting, thyridii obsolete and their intervening space not striate; venter plicate throughout; anus of ♀ acute, with the rufescent terebra distinctly a little exserted. Legs long and slender; calcaria elongate, coxæ not scopulate. Wings flavescent hyaline; stigma and subcosta testaceous, nervures darker; areolet pentagonal, subcoalescent above; nervelet wanting; basal nervure continuous through median. Length, 11–13 mm. ♂ ♀.—Similar to *H. fulgens* Tosq., but with the metanotal areæ distinct and scutellum carinate throughout its apex.—I have seen half a dozen examples of both sexes from the Tero Forest, S.E. of Buddu, at 3800 feet, towards the end of September; from Fort Portal Road, Mbarara, Southern Toro, at about 4000 feet, late in October; from the Durru Forest, Toro, at 4000–4500 feet, a few days later, in Uganda; and from Ilala in the Maramas District, 14 miles east of Mumias at 4500 feet, during the middle of June, in British East Africa.

2. CIBDELUS Tosq.

No one has referred to this species since the ♂ was brought forward (Mém. Soc. Entom. Belg. v. 1896, p. 52, n. 3) from Dinko, Scioa, in Abyssinia, where Ragazzi captured it in 1887. The ♀ is a very dull, claret-red coloured insect, with the metathorax entirely, mesopleuræ except above, hind tarsi, prosternum partly, and apical half of flagellum, black; the frontal orbits triangularly, flagellar band, pronotal margin, and anus white. It is at once recognised by the distinctly and evenly punctate frons; by the shining and very sparsely punctate scutellum, of which the lateral carinæ extend nearly to the apex; the rugulose and white-pilose metanotum with elongate and subhexagonal areola, which in the ♀ is dull and only basally aciculate; and by having the anus from apex of the nigrescent fifth segment clear white. Length, 14 mm.—Captured between Jinja and Busia in some forest to the east of Busoga at 4000 feet, towards the end of July 1911, in Uganda.

Corymbichneumon, g. n.

This new genus differs from *Coelichneumon* Thomson solely in having the scutellum spherical; it stands out from the thorax in the form of a one-third embedded ball, and is not laterally carinate. The only species yet known is remarkable for being of sombre coloration, with both the scutellum and mesonotum conspicuously pale stramineous.

"Monobasic."

1. **carinifer**, sp. n.

♀. A stout, claret-coloured insect with the mesonotum and scutellum dull pale lemon-yellow. Head dull, closely punctate, sometimes black, and very short behind the eyes; palpi pale flavous, cheeks buccate, clypeus broad and apically truncate, hardly discreted from the deplanate and centrally subelevated face. Antennæ black, filiform and stout, with a 10-jointed central white band; basal flagellar joint nearly as long as the two following, which are apically subexplanate. Thorax stout, very finely punctate, black or with only the frenum and tegulæ black; mesonotum, base of propleuræ above, and callosities below radix pale flavous; metathoracic carinæ strong and entire; areola aciculate, twice as long as broad, extending to base and emitting costulæ slightly beyond its centre; spiracles elongate, apophyses wanting. Scutellum pale flavous, globular and glabrous; postscutellum small and concolorous. Abdomen stout, subdeplanate and immaculate; basal segment broad and apically explanate with postpetiole punctate-aciculate; second segment deplanate and finely punctate-aciculate, with large gastrocœli; second and third ventral segments plicate; anus acute and hypopygium remote from base of the black and distinctly a little exserted terebra. *Legs* stout and elongate, indefinitely varied with black; hind coxæ finely punctate, simple; their tarsi setiferous beneath, with large and simple claws. Wings evenly infumate-flavescent; stigma and nervures black; areolet no higher than broad, broad above; discoidal cell subparallel above and below.—♂ differs in having all the above red parts black; the pale flagellar band further from the base; the abdomen and scutellum more deplanate; the metanotum laterally punctate, with no costulæ; the front tibiæ anteriorly testaceous and the anterior coxæ, underside of scape and whole face with mouth-parts, pale flavous. Length, ♂ ♀ 14–18 mm.—A couple of females were captured by Neave in Nyasaland (on the Mlanje Plateau at 6500 feet on November 10th, 1913) and in British East Africa (on the S.E. slopes of Mount Kenya at between 6000 and 7000 feet early in February 1911); the single male, I have reason to believe, is that recorded by the late Colonel C. T. Bingham under the erroneous genus *Lactolus*, in his Report of the Ruwenzori Expedition, No. 13, Hymenoptera (Trans. Zool. Soc. Lond. xix. pt. 2, 1909, p. 179); it was captured at Salt Lake on Ruwenzori at some 7000 to 8000 feet in 1895 by Scott Elliot.

AGLAOJOPPA.

Cameron, Ann. Nat. Hist. vii. 1901, p. 381.

In my Revision of the Ichneumonidæ (iv. 1915, p. 112), this genus is recognised as sufficiently distinct from *Cœlichneumon*; and Tables are given of the European, Oriental, and American species, though none were known from Africa till 1917, when the Ann. S. Afr. Mus. published one that is not dissimilar to the two following kinds.

1. JOHANNIS Cam.

Ichneumon johannis Cameron, Records Albany Museum, i. 1905, p. 245, ♂.

♀. A dull, black species with the mesonotum, scutellum, and sides of thorax sanguineous-red; vertical and a line at the external orbits, flagellar band, postscutellum, apical angles of the three basal and whole of the 6th–7th segments, with inner side of the front tibiæ, white. Head posteriorly short, but nearly as broad as the eyes; frons closely and not finely punctate; face and the undiscreted clypeus closely punctate, apex of latter truncate and, like apex of cheeks, rufescent; labrum exserted and flavidous. Thorax not very dull, very finely punctate, with elongate notauli; metanotum deplanate; areola rectangular, longer than broad, subglabrous, emitting strong costulæ from a little beyond its centre; spiracles elongate; spiracular and lateral areæ alone red. Scutellum deplanate, glabrous, sparsely punctate, carinate only at its base, apically broad and truncate. Abdomen subovate and short; basal segment apically badious with postpetiole punctate, its apical angles and those of the two following segments white, with the third except narrowly in its centre apically white throughout, as also is the anus. Legs normal, badious; hind coxæ mutic. Wings hyaline, stigma black, areolet higher than broad and broad above, nervelet nodiform. Length, 13 mm.—Remarkable for the glabrous and rufescent callosity at the juxta-antennal orbits.—This female was captured at Salisbury in Mashonaland by Marshall during March 1900; the male type, which I have seen, is from the Cape; and W. E. Jones has subsequently found the species at Mfongosi in Zululand.

2. GLABRINOTOR, sp. n.

Very like the last species, but with the head posteriorly buccate and fully as broad as the eyes, not at all black but bright red with only the orbits of its utterly glabrous frons and the palpi white. Thorax strongly nitidulous, with a white callosity beneath radices; mesonotum extremely isolatedly punctate with but short notauli; metathorax deplanate with areola sublinear, fully thrice longer than broad, glabrous and emitting weak costulæ from beyond its centre; external and lateral areæ badious. Scutellum glabrous and glittering with some half dozen punctures, and laterally carinate to its centre. Abdomen fusiform and apically acute; postpetiole badious, sparsely punctate, with no carinæ; fourth and following segments nitidulous; apical angles of the second narrowly and whole of the 6th–7th white. Legs normal; anterior femora and tibiæ internally whitish; hind coxal scopulæ large. Length, 13 mm. ♀ only.—The sublinear metanotal areola is not unlike that of the genus *Cratojoppa* Cam. (Ann. Nat. Hist. vii. 1901, p. 281), in which the scutellar carinæ are wanting, the areolet coalescent above, the head large, &c., which characters do not here obtain.—Found by Neave in Nyasaland to the S.W. of Lake Chilwa on 16th January, 1914.

3. COMPTULUS Tosq.

Ichneumon comptulus Tosquinet, Mém. Soc. Entom. Belg. v. 1896, p. 37, ♀.

♂ ♀. Elongate, punctate, black and somewhat dull. Head quadrate, a little shining, finely punctate; black with all the orbits, except in ♂ the vertical, somewhat broadly white; face broader than long, transversely striate-punctate; clypeus hardly discreted, its apical margin rounded and narrowly, or in ♂ laterally, white. Antennæ short; of ♀ a little dilated centrally, attenuate apically, black, and white-banded; of ♂ also black, serrate, sed fractæ. Thorax rosy, punctate, with sternum black; an elongate line before and a linear callosity below radices, and in ♂ a pronotal mark, white; metathorax convex, strongly punctate, with long griseous pilosity and complete areæ, of which the areola is elongate, apically rounded and more finely punctate, of ♂ centrally nigrescent. Scutellum somewhat convex, smooth or in ♂ punctate, laterally carinate nearly to apex, which in ♂ is, along with carinæ at base and whole postscutellum, white. Abdomen very closely punctate, longer than head and thorax, of ♀ ovate, of ♂ cylindrical; black with apices of the second and third segments narrowly rufescent and the seventh broadly in its centre, along with the ♂ first apically, and three following on either side, white; terebra a little exserted, ♂ valvulæ black and concealed. Legs short and stout, black with front tibiæ dull stramineous; anterior legs of ♀ obscurely red, of ♂ with coxæ white. Wings subhyaline, with an indefinite cloud across the areolet; stigma, nervures and tegulæ black, radix whitish; areolet irregularly pentagonal, nearly coalescent above; nervelet small; lower basal nervure distinctly postfurcal. Length, ♂ ♀ 15 mm.—It was originally described from Togoland, but two males taken by Neave differ so little that I have ventured to regard them as the opposite sex of Tosquinet's species. They occurred in the valley of the South Rukuru River between June 20th and 27th, 1910, at 3000 feet in Nyasaland.

CŒLICHNEUMON.

I do not think any species have yet been recorded from Africa (excepting my note in Revis. Ichn. iv. 1915, p. 121) under this name; but seven of those described by Berthoumieu (Ann. Soc. Ent. France, 1894) under the genus *Ichneumon* from Algeria seem to belong here, with *C. hæmorrhoidalis* Grav., *C. rudis* Fonsc., and *C. sinister* Wesm., which extend from southern Europe. I find *Platylabus maculiscutis* Cam. and *Ichneumon natalensis* Cam. to also belong here; and the dozen species is completed by one brought forward in the Ann. S. Afr. Mus. by me in 1917. Probably some of Tosquinet's and Kreichbaumer's *Ichneumones* will also have to be included, when the types are re-examined. *Holcichneumon* Cameron (Ann. Mus. Transvaal, ii. 1911, p. 175) is synonymous.

Table of some African Species.

(8)	1.	Black or castaneous, with pale flavous-marked thorax.	
(3)	2.	Hind coxæ stoutly scopulate; scutellum glabrous.	1. *scopulifer* Morl.
(2)	3.	Hind coxæ mutic; scutellum distinctly punctate.	
(5)	4.	Metanotal areola longer than broad; scrobes tuberculate	2. *cornellifer* Morl.
(4)	5.	Metanotal areola not longer than broad; scrobes simple.	
(7)	6.	Abdomen and hind legs red; petiolar area black.	3. *maculiscutis* Cam.
(6)	7.	Abdomen mainly and hind legs black; petiolar area pale-marked	4. *natalensis* Cam.
(1)	8.	Testaceous; rarely with head and thorax black-marked.	
(12)	9.	Mesonotum nitidulous; head and thorax pale stramineous-marked.	
(11)	10.	Postpetiole aciculate; gastrocœli large; scutellum white	5. *sublunifer* Morl.
(10)	11.	Postpetiole punctate; gastrocœli small; scutellum red	6. *geminifer* Morl.
(9)	12.	Mesonotum dull and shagreened; rarely dull flavous-marked.	
(14)	13.	Areola narrow and elongate; lower basal nervure postfurcal	7. *testaceus* Cam.

(13) 14. **Areola** broad, not elongate; lower basal nervure continuous.
(20) 15. Second abdominal segment neither striate nor black-banded.
(17) 16. Scutellum convex and subcircular; areola glabrous 8. *globulifer* Morl.
(16) 17. Scutellum deplanate and elongate; areola dull and shagreened.
(19) 18. Second segment transversely impressed; gastrocœli obsolete .... 9. *sulcifer* Morl.
(18) 19. Second segment entire; gastrocœli large and triangular .... 10. *thyridifer* Morl.
(15) 20. Second segment black-banded and strongly striate. 11. *striatifer* Morl.

1. SCOPULIFER, sp. n.

A *claret-coloured* and somewhat shining female, with the occiput and frenum indefinitely *black*; all the orbits but the temporal, the mandibular base, sides of clypeus, flagellar band, prothoracic margin, lines before and beneath radix, a central mesonotal mark, two more on mesopleuræ, sides of petiolar area, the scutellum and postscutellum, *stramineous-white*. Head posteriorly short, but as broad as the eyes; frons distinctly and face not closely punctate, the latter transverse, centrally prominent and not discreted from the apically truncate clypeus, which is centrally subdentate. Thorax shining, with distinct notauli; metathorax evenly punctate and not dull; areola obviously longer than broad, parallel-sided, glabrous, apically incomplete and emitting weak costulæ from its centre. Scutellum deplanate, subquadrate, glabrous with a very few fine and scattered punctures, apically truncate and not at all laterally carinate. Abdomen elongate fusiform with apices of segments a little prominent; three basal segments closely punctate and somewhat dull; postpetiole and base of second segment punctate-striate, the former basally bicarinate; gastrocœli large and deeply impressed; terebra black and a little exserted. Legs indefinitely nigrescent red with apices of front coxæ broadly, and of the intermediate narrowly, white; hind coxal scopulæ large. Wings hyaline, stigma and tegulæ black, radix white; areolet pentagonal, broad above; nervelet wanting, second recurrent nervure externally produced at its centre. Length, 12 mm. ♀ only. Captured at Mlanje on 15th August, 1913, in Nyasaland.

2. CORNELLIFER, sp. n.

A *black* species with abdomen except petiole, metathorax except petiolar area, mesopleuræ and most of the legs, *red*; all the orbits, cheeks, face except a central didymate mark, clypeus, mandibles, the ♀ flagellar band, prothoracic margin, lines before and beneath anterior radix and behind the posterior, a central mesonotal and two mesopleural marks, scutellum, postscutellum, apical angles of the basal segment minutely, anterior coxæ and trochanters entirely and the hind ones discally, *stramineous*; ♂ also has the basal segment except its angles black, and the petiolar area stramineous. Remarkably like the last species but differing in its colour, puncturation, especially of the frons and mesonotum and scutellum; in the much stronger costulæ, at least basally black first segment with its pale apical angles; in the indication of a nervelet and the simple second recurrent nervure; in its somewhat stout facial tooth between the scrobes; and also in the lack of ♀ coxal scopulæ. Length, 14–15 mm. ♂ ♀.—The type is from Blantyre in Nyasaland on 9th June, 1910 (*Dr. J. E. S. Old*); and the male occurred in the Gold Coast about the same time (*W. P. Lowe*).

3. MACULISCUTIS Cam.

Platylabus maculiscutis Cameron, Ann. S. African Mus. v. 1906, p. 179, ♂; *Ichneumon transvaalensis* Cameron, Ann. Mus. Transvaal, ii. 1911, p. 174, ♀.

An examination of both types convinces me of the above synonymy. The ♂ is from Klerksdorp in November 1890, and the ♀ is labelled "Fonteinen, 24th April, 1905," both in the Transvaal. A pair of homotypes were taken in South Africa so long ago as 1845, and in the Ruo Valley, Nyasaland, at 2000 feet on October 25th, 1913.

4. NATALENSIS Cam.

Ichneumon? natalensis Cameron, Ann. S. African Mus. v. 1906, p. 160, ♂.

The details contained in the above Table are drawn from the type in the British Museum. Another ♂, also labelled "type" by Cameron, is in the S. African Museum; taken at Malvers in Natal by Barker.

5. SUBLUNIFER, sp. n.

A small, *fulvous* and not testaceous female with the occiput, vertex, frons, and scrobes to radicule, antennæ except underside of scape and their white band, mesonotum and a mark in each of the external and dentiparal areæ, *black*; remainder of the head, prothorax, elongate callosities before and beneath radices, two discal mesonotal lines, mesopleuræ except speculum, scutellum except lateral carinæ, postscutellum, anterior coxæ and trochanters and disc of hind coxæ, very *pale stramineous*. Head transverse, narrower than eyes and posteriorly but slightly emarginate; face closely but weakly, and frons obsoletely, punctate; clypeus subdiscreted, apically truncate and centrally a little impressed. Mesonotum very closely punctate and not shagreened, with distinct though fine notauli; metanotum shining, finely punctate-aciculate, with petiolar area long and broad, discreted; areola proportionately short, subsemilunate, broader than long, basally rounded and emitting weak costulæ from its centre. Scutellum deplanate, glabrous, laterally carinate to near its truncate apex, before which it is traversed by a few longitudinal striations.

Abdomen immaculate fulvous, fusiform; postpetiole centrally very finely aciculate, laterally punctate; gastrocœli large, deep and transverse, with the narrow intervening space evenly punctate; terebra black and exserted. Legs normal; hind coxæ mutic. Wings hyaline; radix and tegulæ stramineous, stigma castaneous; areolet small and pentagonal, nervelet nodiform; basal nervure continuous through the median. Length, 7 mm. ♀ only.—Captured at Northern Buddu at 3800 feet during the middle of September 1911 in Uganda.

6. GEMINIFER, sp. n.

A *rufescent-testaceous* female, very like the last but larger with the mesonotum nitidulous and only sparsely punctate, its disc *red* and sides occasionally *black*; the scutellum is rufescent with its lateral carinæ and instriate apex *stramineous*; the metanotal areola, though similarly shaped, is much larger; the abdomen testaceous with postpetiole evenly and distinctly punctate throughout; gastrocœli small and much narrower than their intervening space; terebra basally rufescent; coxæ testaceous, with no stramineous markings. Length, 12-14 mm. ♀ only.—A couple of females (one with the metathorax testaceous and only geminate spots as in the last species; the other with the external and dentiparal areæ black and a stramineous pleural streak) at Mlanje in September and October 1913 at 2300 feet in Nyasaland. Also found by W. E. Jones, during March 1917, at Mfongosi in Zululand.

7. TESTACEUS Cam.

Holcichneumon testaceus Cameron, Ann. Mus. Transvaal, ii. 1911, p. 175, ♀.

I have examined this unique, bred in the Transvaal, and find it belongs here.

8. GLOBULIFER, sp. n.

Males differing from the next species (*C. sulcifer*) solely in their general *flavous* coloration, lack of metapleural marks; in the subglabrous postpetiole, simple second segment with normal gastrocœli; in the *black* ocellar region, hind tarsi and hind tibiæ, with pale calcaria; in the subcircular metanotal areola, the apically coalescent alar areolet; and in the subconically elevated scutellum with long black pilosity. Length, 13 mm. ♂ only.—A couple of males were found at Kibwezi at 3000 feet, at the beginning of April 1911, in British East Africa; and in the Tero Forest, S.E. of Buddu, at 3800 feet, at the end of September 1911, in Uganda.

9. SULCIFER, sp. n.

A very dull, *rufescent-testaceous* species with only the face *subflavidous*; flagellum except the central white band, sides of mesonotum, a common streak in the external and dentiparal areæ, alone *black*; apices of the hind tibiæ and their calcaria nigrescent. Head obsolete behind the eyes; frons and the centrally elevated face hardly punctate; clypeus not discreted, apically truncate; mandibles not apically darker. Mesonotum dull and shagreened, with short notauli; metathorax dull with dentiparal areæ transaciculate; areola dull and shagreened, a little longer than broad and rounded at both extremities; costulæ utterly wanting. Scutellum elongate-triangular, deplanate, shining and sparsely punctate, with no pilosity, laterally margined to near apex. Abdomen elongate-fusiform, unicolorous; basal segment closely and evenly punctate; the second transversely impressed throughout at its basal fourth; gastrocœli very small; terebra black and a little exserted. Legs somewhat short and not slender, coxal scopulæ wanting. Wings flavescent-hyaline; radix, tegulæ, and stigma entirely pale testaceous; areolet pentagonal and broad above; nervelet and another in second recurrent nervure, short. Length, 12 mm. ♀ only.—Several females captured in British East Africa (on the Yala River at the southern edge of the Kakumga Forest, at about 5000 feet, towards the end of May 1911) and Uganda (in the Durru Forest, Toro, at 4000–4500 feet, at the end of October 1911; and at Fort Portal Road, Mbarara, in Southern Toro, at some 4000 feet, a day or two earlier). Also taken by G. F. Leigh on 1st March, 1910, at Pinetown in South Africa.

10. THYRIDIFER, sp. n.

A very dull, *rufescent-testaceous* female with only the face and two elongate vittæ on the black mesonotum *subflavidous*. Very similar to the last species, but differing in a few essential details; ocellar region and centre of occiput confluently, mesonotum centrally as well as laterally, scutellum centrally, basal sulcus only of metathorax, with whole of the hind tibiæ and tarsi, *black*; metanotal areola smaller, emitting distinct though weak costulæ; centre of scutellum more closely punctate and subconvex; postpetiole obsoletely punctate-aciculate; gastrocœli deeply impressed, somewhat large and as broad as their intervening space; areolet coalescent above, with the second recurrent nervure simple. Length, 14 mm. ♀ only.—Harrar in Abyssinia, during 1912 (Collector ignot.).

11. STRIATIFER, sp. n.

Rufescent-testaceous with the face and orbits indefinitely, mesonotal margins and whole hind tarsi, *flavidous*; ocellar region circularly, flagellum except the white band, sides only of mesonotum broadly, whole external areæ, spiracles of basal segment, a transfascia before centre of the second segment and at base of the third, *black*. Head posteriorly strongly emarginate, with obsoletely punctate frons; flagellum serrate. Anterior margin of mesonotum sulcate and strongly elevated; metanotum punctate, with the dentiparal areæ aciculate and areola hexagonally quadrate, emitting strong costulæ from its centre. Scutellum subquadrate, deplanate, elevated from base to the truncate apex, laterally margined throughout, and much higher than metanotum. Abdomen dull and closely punctate with the postpetiole, second segment to near its apex and the third to centre, longitudinally striate; gastrocœli deeply impressed. Areolet triangular, almost broader than high, coalescent above. Length, 11 mm. ♂ only.—Doubtless this species were more correctly placed (on account of its distinctively striate basal segments, the apices of which may be said to be slightly produced laterally) in one of the more typically Joppid genera, though its facies are sufficiently analogous with the present one. A single male was captured at Chagwe in the Mabira Forest at some 3500 feet during the middle of July 1911, in Uganda.

Tribe ICHNEUMONIDES.

Subtribe **Oxypygini.**

LAGENESTA.

Head large and not strongly constricted posteriorly; occiput margined; labrum strongly prominent, clypeus apically truncate; mandibles bidentate, the upper tooth the longer. Antennæ stout, dilated beyond their centre. Metanotum transversely punctate, with no distinct areæ; petiolar region transversely carinate below its centre. Scutellum deplanate and not laterally carinate. Abdomen neither punctate nor striate, with sides of segments not angularly prominent apically; apical third of petiole broadly dilated; gastrocœli large and stoutly striate, but not deeply impressed; ventral plica strong on second and third, weak on fourth and fifth, segments. Legs stout with tarsal joints spinose, explanate and basally constricted; hind femora extending to fourth segment. Areolet large, pentagonal, and broad above, emitting recurrent nervure from its centre; radial nervure apically reflexed.

The above are the characters assigned to this genus by Cameron, at the time of its erection (Ann. Nat. Hist. vii, 1901, p. 376); but they are entirely drawn from the female of one species, of which he knew the male later (lib. cit. xi. 1903, p. 185) and the only other published species four years afterwards (Zeits. Hym. u. Dipt. v. 1905, p. 86, ♀). These are all from the Hills of northern India, whence I have seen a third kind *; and have no doubt

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* LAGENESTA MONITOR, sp. n.

A cylindrical, brick-red and cyaneous-black species, with infumate wings. Head cubical and broader than thorax, with the frons to ocelli and mandibular apices alone black; occiput strongly margined; vertex centrally rugose, laterally smooth and behind the eyes strongly elevated into stout and obtuse spines; frons rugose and centrally produced into a stout spine between the scrobes; temples longer than that the original account of the genus will have to be sufficiently modified to embrace the following additional African kinds, which I have compared with the types of both Cameron's species. He himself, while placing it in the Joppides, was doubtful of its position and remarks that it "does not fit well into any of Kriechbaumer's groups of the Hemijoppinæ"; as a matter of fact, the total lack of basal metanotal sulcus in the genotypical specimen, with its very flat scutellum, places it (I consider, certainly) in the Ichneumonides. Of palæarctic groups, it is most closely allied to *Melanichneumon* and especially *Eupalamus*.

1. SINIFER, sp. n.

A large and stout, dull black species, with head and mesonotum shining; wings evenly nigrescent, head entirely red, antennæ and hind tarsi white-banded. Head and scape rich red and glabrous; former strongly buccate behind eyes and nearly as long as broad, posteriorly strongly emarginate, with occiput bordered; scrobes externally produced below; face and clypeus sparsely and coarsely punctate, the latter hardly discreted, apically truncate, laterally rounded and elevated; mandibles stout and sparsely punctate, with teeth black. Antennæ subfiliform; of ♀ very slightly dilated beyond centre, with the 10th to 18th flagellar joints white; of ♂ subserrate, with the 19th to 25th flagellar joints white. Thorax very stout and black with prothorax and in ♀ apices of both scutellum and postscutellum with most of frenum, rufescent; mesonotum glabrous, with a few irregular fine punctures; notauli short and very deeply impressed; metathorax evenly scabriculous throughout, not basally sulcate; of ♂ with petiolar carina alone distinct; of ♀ with areola weak, elongate-oval, longer than broad, apically acuminate, with its carinæ weaker than the centrally emitted costulæ; petiolar area short and not discreted;

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eyes; face quadrate, longitudinally punctate and laterally sulcate before the elevated orbits; clypeus continuous, smoother, apically broadly rounded with its angles strongly elevated and centre minutely bidentate; labrum concealed, cheeks not elongate, lower mandibular tooth slightly the shorter. Antennæ setaceous, not very slender, red with the apical third black and central joints subserrate. Thorax cylindrical, dull and closely punctate, brick-red with all the sutures black; mesopleuræ, dentiparal areæ and the parallel-sided areola all apically produced; metanotum deplanate and double as long as petiolar area; basal area obsolete, costulæ wanting: spiracles linear. Scutellum and postscutellum red, evenly punctate and subdeplanate, with basal fovea and carinæ black. Abdomen parallel-sided and slender, double as long as thorax, obsoletely punctate, subnitidulous and black, with venter concolorous and only the second and third segments strongly plicate; basal segment glabrous and red, with obsolete punctures and a discal longitudinal fovea; thyridii wanting, valvulæ exserted. Legs elongate and somewhat slender; deep red with hind tibiæ and tarsi alone black; hind femora extending only to apex of second segment. Wings ample and evenly infumate; radix and tegulæ red, stigma and nervures black; areolet exactly pentagonal, broad above, emitting the broadly bifenestrate recurrent nervure from its centre; discoidal cell nearly parallel-sided; nervelet pellucid, lower basal nervure postfurcal; nervellus intercepted at its lower third. Length, 22 mm. ♂ only. Type in Mus. Brit. Assam.

spiracles large and apophyses wanting. Scutellum deplanate, glabrous with a few fine scattered punctures, laterally carinate to near apex. Abdomen dull and elongate-fusiform; basal segment shagreened or in ♂ nearly smooth, with postpetiole strongly explanate and flat; second segment not at all striate, its gastrocœli deep and a little narrower than the intervening space, plica on second to fourth ventral segments, and disc of ♀ seventh segment, entirely white; terebra subexserted, black. Legs normal; inner side of anterior tibiæ and of front femora, with whole hind tarsi from second segment, white; hind coxæ of ♀ with large, brown scopulæ; claws large. Wings deeply infumate throughout, with cyaneous reflection; areolet triangular and coalescent above; nervelet short; basal nervure continuous through median; first recurrent nervure (of Ichn. Brit. i. 1903, p. xxxvi) sinuate at apex of anal nervure. Length, 16–17 mm. ♂ ♀.—The ♂ was found in some forest land between Jinja and Mbwago's, east of Busoga, at about 4060 feet on 28th July, 1911, in Uganda; and females at Mount Mlanje on 29th November, 1912 and again on 4th February, 1913, in Nyasaland. W. E. Jones took another ♀ during March 1917, at Mfongosi in Zululand.

2. DUPLICATOR, sp. n.

A large, rich crimson species, with slightly flavescent-hyaline wings; frons triangularly and broadly to below ocelli, the ♀ 10th to 16th flagellar joints, the sixth and seventh segments discally, ventral plica and apices of all the ventral segments, white; mandibular apices, remainder of flagellum and the whole of third to fifth segments, black; hind coxal scopulæ strong, but not large. In sculpture this species differs from the last in little but its rugulose metanotum with discreted petiolar area, much shorter capital vertex, distinctly postfurcal lower basal nervure and broader areolet which is not laterally coalescent above.—The ♂ also has the whole clypeus, face, centre of external orbits, underside of scape, pronotal margin, a linear callosity below radix, the postscutellum, apical margins of the second and third segments narrowly, and the three apical joints of its basally black hind tarsi, white. Length, 17 mm. ♂ ♀.—The female is from 2300 feet at Mlanje on 21st October, 1913, in Nyasaland; and the male was found at South Kavirondo at 4200 feet early in May 1911 in the Upper Kuja Valley of British East Africa. In Zululand, Mfongosi, South African Museum.

3. TRIPLICATOR, sp. n.

So similar to *L. duplicator* as to need no detailed description; therefrom I am able to distinguish it only by its rather less clear red coloration, smaller size, more slender and more parallel-sided abdomen, much narrower frontal white markings, the entirely crimson third abdominal segment, and the utterly hyaline wings with their areolet quite coalescent above and basal nervure exactly continuous through the median. Length, 15–16 mm. ♂ ♀.—Apparently not an uncommon species about Mlanje, where a series was captured during January, February, and March, 1913 and 1914.

4. TRIANGULIFER, sp. n.

A stout, shining, black female with the scutellum and its frenal sides, basal foveæ and centre of mesonotum throughout, mesosternum except centrally at the base, meso- and meta-pleuræ entirely, rosy; both clypeus and frons except longitudinally in their centre, central flagellar band except below, postscutellum, apices of first and sixth segments narrowly, of the second broadly on either side and whole of the seventh with most of venter, anterior coxæ and (excepting a discal streak) trochanters, with the four apical joints of hind tarsi, white; anterior legs mainly pale, hind femora and tibiæ rufescent black. Wings hyaline; hind coxal scopulæ large. Mesonotum glittering and only sparsely punctate; scutellum absolutely glabrous, laterally black carinate to near its truncate apex; metanotum evenly and scabrously punctate with no areæ but an elongate-triangular (wedge-shaped) portion, gradually contracted apically, glabrous and nitidulous; pleural carina strong. Postpetiole deplanate, explanate and shagreened. Stigma black; areolet coalescent above; lower basal nervure a little postfurcal. Length, 15 mm. ♀ only.—A conspicuous species with, I believe, unique metanotal structure; and obviously belonging to the present genus by the analogy of the puncturation and frontal-colour distribution, besides more pertinent characters, though superficially very like *Melanichneumon*.—It was found in the Durro Forest, Toro, at fully 4000 feet, between 23rd and 29th October, 1911, in Uganda.

MELANICHNEUMON.

This genus was divided from the broad division, *Ichneumon* in the Wesmaelian sense, by Prof. Thomson so long ago as 1893 (Opusc. Entom. xviii. p. 1954); but was therein again merged by both Berthoumieu in 1894 and Schmiedeknecht in 1903. Thomson's groups are perfectly natural and are now, all too slowly, coming into general recognition: they were adopted by me in 1903. Consequently, we must bear in mind that in the case of the present and few following genera, other species may already exist under the old broad heading of *Ichneumon*. Smits van Burgst has recorded (Tunisian Hymen. 1913) three European species of *Melanichneumon* extending to North Africa; I have described two new kinds (Ann. S. Afr. Mus. 1916); and Dr. Roman has shown (Zool. Bidr. Upsala, i. 1912, p. 262) that *Ichneumon leucophthalmus*, Thunberg 1822, belongs here and that its male is *I. fimbriator*, Thunb.

1. CARINIFER, sp. n.

A stout and closely punctate but not very dull, black female with no pale antennal band; frontal and centre of external orbits, labrum, mandibles and cheeks, basal half of flagellum indefinitely, and the anterior legs except basally, fulvidous; elongate callosities before and beneath radix, a circular central mesonotal mark, whole scutellum and postscutellum, alone stramineous. Head transverse; face and clypeus strongly and evenly punctate, not discreted, the latter slightly produced centrally. Flagellum filiform, neither explanate nor apically attenuate. Notauli short and deep; metathoracic carinæ very strong, with the external dentiparal outwardly curved at its base; areola subaciculate, basally glabrous, rounded and there touching postscutellum, apically subtruncate; spiracles large, apophyses wanting. Scutellum deplanate, glabrous with a few fine scattered punctures, not laterally margined. Abdomen stout and fusiform, immaculate black; basal segment stoutly bicarinate to the closely and evenly punctate postpetiole; gastrocœli large and broader than the shortly striate intervening space; anus nitidulous and obsoletely punctate; the third and obscurely ochraceous second ventral segments plicate, hypopygium remote from terebral base. Legs stout and not short, black with anterior femora, tibiæ and the front tarsi clear red; coxæ not scopulate. Wings hyaline; areolet pentagonal, broad above; internal cubitus straight, with no nervelet; stigma castaneous-black; lower basal nervure distinctly postfurcal. Length, 17 mm. ♀ only.—This species has much the facies of *Hepiopelmus leucostigmus*, Grav., with the anus more acute and hypopygium remote.—Harrar in Abyssinia during May 1911 (Collector ignot.).

2. MELANOPTERUS, sp. n.

An extremely dull and closely shagreened, black species with only the laterally carinate scutellum nitidulous; flagellar band alone white; wings strongly infumate. Head transverse, constricted behind the eyes; frons evenly, face and the undiscreted clypeus closely punctate, with apex of the latter a little rounded; labrum and palpi obscurely rufescent. Flagellum centrally subexplanate and apically attenuate. Notauli short and deeply impressed; metanotum with only the petiolar carinæ strong; areola and costulæ obsolete, the former shaped as in the last species, though sculptured as remainder of metanotum; spiracles large, apophyses short and acute. Abdomen fusiform and immaculate; postpetiole punctate-shagreened; gastrocœli wanting, thyridii shining, intervening space not striate; venter plicate throughout. Legs normal; coxæ not scopulate; front tibiæ and tarsi obscurely rufescent. Wings nigrescent throughout; areolet coalescent above; cubital nervure curved, with no nervelet; basal nervure continuous through the median. Length, 14 mm. ♀ only.—The outline is similar to that of *M. leucomelas* Gmel., but the head is posteriorly shorter.—The type was captured on Mount Kokanjero to the S.W. of Elgon at 6400 feet on 8th August, 1911, in Uganda.

3. GLAUCOPTERUS, sp. n.

A somewhat dull and evenly punctate-shagreened, black male with the laterally carinate scutellum more shining; front tibiæ alone internally whitish; wings flavescent. This might well be the alternate sex of the last species, with which the sculpture and colour mainly accord, were it not that the mandibles are rufescent, the metanotal areola and costulæ are strong, the apophyses wanting, the abdomen subcyaneous with gastrocœli deeply impressed though narrower than the substriate intervening space, and the wings deeply clear flavescent with only their apices infumate, the radix and costa, stigma and nervures clear flavous, and the lower basal nervure distinctly postfurcal. Length, 13 mm. ♂ only.—Very similar, superficially, to the males of my *Pimpla glaucoptera* (Revis. Ichn. iii. 1914, p. 68) from Uganda and British E. Africa.—Taken on a plateau of Mount Mlanji at about 6500 feet on 1st May, 1910, in Nyasaland.

LEPTOTHECUS.

Head with the clypeus apically truncate and labrum prominent; cheeks usually strongly buccate. Antennæ broadly pale-banded and not considerably dilated beyond their centre. Thorax unusually cylindrical; metathorax large and distinctly longer than broad, apically somewhat straight and abruptly declivous; areola elongate-hexagonal, fully twice longer than broad, apically truncate and often basally incomplete; apophyses spinate. Scutellum deplanate. Abdomen slender, longer than head and thorax, apically narrowed from base of fourth segment, with seven visible dorsal segments: petiole slender and elongate, becoming gradually a little explanate towards its apex; pygidium large and two-thirds the length of the penultimate; ventral plica obsolete; terebral valvulæ strongly prominent, remote from hypopygium and as long as the white-marked two apical segments. Legs with tarsi spinose; hind legs much the longest, with their tibiæ basally constricted. Wings with areolet pentagonal and constricted above; nervelet distinct.

In his erection of this genus, Cameron (Entomologist, xxxvi. 1903, p. 240) correctly places it in the Oxypygini, and an examination of the genotype enables me to emend it slightly, as above given. Its author considered that it "may be known by the elongated spined median segment, with its elongated coffin-shaped areola, confluent with the lateral areæ at the base; by the long projecting ovipositor; and by the smooth impunctate abdomen, with its small gastrocœli." It has the facies of *Stenichneumon* Thoms., but the face is not apically constricted, the cheeks are buccate in the typical species and the juxta-coxal is entirely discreted from the pleural area; the dull and shagreened thorax, of both the known kinds (lib. cit. p. 260 et Zeits. Hym. u. Dipt. v. 1905, p. 142) from northern India, is similar to that of *S. ochropis* Gmel. Though not agreeing in every particular with the diagnosis of *Leptothecus*, which was based on a single Oriental female, the following kinds are sufficiently homogeneous and differ from *Hoplismenus* so little (besides the lack of basal metanotal sulcus) that I should expect to find it mixed among Szépligeti's conception of that genus.

1. ALUTACEFER, sp. n.

A very dull and alutaceous, black species with sparse pure white, and the thorax with red, markings. Head short and not extending posteriorly behind the eyes; ocelli at vertex of the abrupt occipital declivity; face closely punctate, its centre and the continuous clypeus more coarsely punctate, centre of the latter slightly emarginate with its glabrous lateral angles white and subelevated; palpi, except their apical joint, and the exserted labrum white; frons transversely pure white throughout. Antennæ attenuate, and a little explanate, beyond their central partial white band. Thorax deplanate and rosy-red with prothorax, sides of mesonotum and disc of metanotum black; notauli very small, speculum not shining; areola double as long as broad, basally acuminate but not reaching base of metathorax, with weak costulæ; petiolar area short, basal area triangular and hardly carinate; spiracles elongate, apophyses strong and acute. Scutellum red, deplanate, somewhat elongate and laterally strongly carinate to the flavidous apex. Abdomen with apices of the two basal segments, whole of the sixth and seventh, and of the second to fourth ventral ones, white; terebra black and distinctly exserted, with its extreme base covered by hypopygium; first segment evenly punctate and somewhat narrow, thyridii of the second lateral and longitudinally linear. Legs elongate and slender; anterior brick-red with coxæ and trochanters white, their tarsi and the intermediate femora nigrescent; hind legs black, with the second to fifth tarsal joints pure white. Wings hyaline and not broad; tegulæ and costa black, stigma ferruginous; areolet as broad as high, laterally coalescent above; discoidal cell narrow and subparallel, with obsolete nervelet; basal nervure subcontinuous.—♂ differs in having part of the facial and external orbits, whole clypeus but not centre of the frons, white; the flagellum is setigerous and more elongate; the apical half of the metanotum black-and-red, with white genital valvulæ. Length, 11–13 mm. ♂ ♀.—Var. ♂. Head black with the palpi and frontal orbits alone white. Another ♂ has the legs basally nigrescent-red.—Males were captured in the Tero Forest of Uganda during July 1912 (*C. C. Gowdey*). Females at Unyoro about 3400 feet in the Budongo Forest of Uganda in mid-December 1911. Two additional females, also from Uganda, have the centre of scutellum and a dot on the postscutellum white, the metathorax entirely dull rosy and its areæ obsolete; they occurred at Entebbe during September 1911 and at some 3500 feet in the Mabira Forest, Chagwe, in the middle of the preceding July; and Jones took a ♂ at Mfongosi in Zululand, January, S. African Museum.

2. PUNCTIFER, sp. n.

A very dull and closely punctate, black male with sparse white marks, and the thorax mainly red. Extremely similar to the last species but with the mesonotum punctate, in place of alutaceous; the head immaculate; cheeks narrow, clypeus extremely small; palpi and the entire scape alone white; flagellum longer and not setigerous: notauli deeply impressed and elongate; areola small, apophyses obsolete; petiole linear; genital valvulæ, anterior legs basally and the hind tarsi, black; nervelet wanting. Length, 13 mm. ♂ only.—Found by C. C. Gowdey in the Tero Forest during July 1912, in Uganda.

3. MESONOTIFER, sp. n.

A very dull and alutaceous, black species with sparse pure white, and the thorax with red, markings. Head by no means short, though obliquely constricted, behind eyes; cheeks broad; face deplanate, definitely and somewhat confluently punctate, not discreted from the more sparsely punctate and apically truncate clypeus; mandibles slender and black; palpi, clypeus, and the glabrous frons pure white. Antennæ elongate and subexplanate beyond the mainly white central band, apically attenuate, with the eight basal flagellar joints elongate. Thorax rosy-red with prothorax, mesonotum laterally, frenum and disc of metanotum basally from the small but acute apophyses, black; mesonotum apically produced at its centre, notauli short; metanotum closely punctate with areola elongate-triangular, apically attenuate and not extending to base, emitting weak but entire costulæ from near its base; spiracles elongate. Scutellum convex, shining and glabrous with a few sparse punctures, its sides carinate to near apex which is, like the postscutellum, flavidous. Abdomen elongate with apices of two basal segments and base of the third narrowly, with whole venter, testaceous; seventh and apex of sixth segments white; thyridii of the second small and laterally linear; terebra black and shortly exserted. Legs slender and strongly elongate, nigrescent with apex of hind metatarsus to middle of its onychium white, hind trochanters beneath and apices of their coxæ pale testaceous; anterior legs internally rufescent or testaceous; claws large and simple. Wings hyaline and not broad; tegulæ and costa black, stigma ferruginous; areolet no higher than broad, laterally coalescent above, emitting recurrent nervure before its centre; lower basal nervure postfurcal.—♂ differs in its white mandibles, immaculate black clypeus and frons, more slender flagellum; deep and crenulate notauli, extending to scutellar fovea; sublinear and strongly white-pilose basal segment; large and black genital valvulæ; and in having the hind tarsi white, with only the metatarsal base and very small claws black. Length, 15–17 mm. ♂ ♀.—The typical female was taken at Masaka in Uganda early in November 1913 (*C. C. Gowdey*). Cotypes are from the Tero Forest of Uganda in July 1912, along with a couple of males; another male at Mwera, near Entebbe, on 26th of the next month (*Gowdey*). In the middle of August 1911, on the Siroko River at the west foot of Mount Elgon at an altitude of 3600 feet, also in Uganda.

STENICHNEUMON.

Van Burgst has recorded three European species of this Thomsonian genus from northern Africa, and Cameron has attributed to it, with a query, another species from the south of the Continent (Records Albany Mus. i. 1905, p. 229). It would appear uncommon here, and I have seen but one species:—

1. OCHRACEATOR, sp. n.

An extremely dull, pale ochraceous male with indefinite black markings, and the hind legs dark-lined with white tarsi. Head strongly transverse and abruptly declivous immediately behind eyes; occiput and centre of frons nigrescent; face superficially and clypeus very sparsely punctate, the latter not discreted and apically truncate. Flagellum black, with joints 14 to 24 white; reliquæ absent. Thorax dull and alutaceous, higher than broad; metanotum and mesonotum with basal marks, scutellar carinæ and the postscutellum, indefinitely nigrescent; areola obsolete, obliquely and irregularly striate, subhexagonal, emitting obsolete costulæ; petiolar area shagreened, with no carinæ; spiracles elongate, apophyses absent. Scutellum deplanate and punctate, apically truncate, with an elevated carina throughout its margin. Abdomen indefinitely black with apices of the segments narrowly, valvulæ and venter, pale. Legs elongate; hind ones with base of tarsi, inner side of tibiæ and a discal line on femora, subnigrescent; remainder of hind tarsi white. Wings hyaline; tegulæ and radix pale, stigma and nervures black; areolet small and pentagonal, emitting the strongly sinuate recurrent before its centre; nervelet wanting; basal nervure continuous through the median. Length, 11 mm. ♂ only.—Captured in Lagos, Western Nigeria, on 13th February, 1911, by W. A. Lamborn.

CRATICHNEUMON.

No species of this Thomsonian genus have yet been reported from Africa, apart from such as may be included in the main genus *Ichneumon* by Tosquinet, &c. I consider the following is sufficiently typical to be placed here, though several of its features are abnormal.

1. TESTACECOLOR, sp. n.

A stout and dull, clear testaceous female with only the sternum, frons and frontal orbits substramineous; flagellum alone black, white-banded; wings flavescent. At once known in the present genus by its unique coloration; the aciculate-glabrous, and laterally punctate, postpetiole; the small, subquadrate and nearly glabrous metanotal areola, with or without distinct central costulæ; by the pale stigma; and by having all the simple coxæ curiously deplanate beneath. Length, 13–14 mm. ♀ only.—The alutaceous thoracic sculpture relates this species to *C. rubricosus* Hlmgr., but the head is very broad and distinctly broader than thorax.—Found at Unyoro in the Budongo Forest in the middle of December at 3400 feet; and at Chagwe in the Mabira Forest in the middle of July at 3500 feet, in Uganda, during 1911.

BARICHNEUMON.

Berthoumieu has described three species from Algeria; Burgst has discovered that three of the palæarctic kinds extend to Tunis; and I have brought forward (Ann. S. Afr. Mus. xv. 1916, p. 364) another from the Cape. This Thomsonian genus will probably be found here over at least the more temperate regions.

1. CONCINNATOR, sp. n.

A small and evenly punctate, black male with vertical dots and base of scape beneath obscurely, and all the tibiæ and femora clear, fulvous; wings subinfumate throughout. Head not strongly constricted posteriorly; frons and face closely, the apically a little rounded clypeus very sparsely, punctate. Flagellum short and setaceous, hardly longer than head and thorax, apically pale beneath. Thorax stout, cylindrical, shining and evenly punctate; notauli indicated; metanotal areola triangular, its basal carina convex and apical concave, emitting strong costulæ a little beyond its centre; petiolar area elongate, discreted with very strong lateral carinæ; spiracles small and elongate, apophyses wanting. Scutellum punctate and shining, only basally carinate. Abdomen cylindrical and dull; basal segment stout, gradually explanate, with the postpetiole subbicarinate and evenly punctate; gastrocœli small and superficial, intervening space not striate; ventral segments two to four plicate, valvulæ black and not exserted. Legs neither short nor slender; all the femora and tibiæ fulvous, with the front tibiæ internally paler. Wings somewhat small, evenly brunneous throughout; stigma black; areolet obliquely pentagonal, broad above, emitting the sinuate recurrent nervure beyond its centre; lower basal postfurcal. Length, 8 mm. ♂ only.—The sculpture and disposition of the wing nervures are very like *B. gemellus* Grav., though the whole puncturation is less close and more distinct.—Two or three males were found in Abyssinia, probably about Harrar, in 1910 (Collector ignot.).

2. INCUBITOR Linn.

A female of this species, differing from the somewhat uncommon palæarctic form with entirely black legs only in its lack of white flagellar and anal markings, was discovered on the western slopes of Mount Kenya, on the Meru-Nyeri Road at between six and eight and a half thousand feet, in the middle of February 1911, in British East Africa.

3. PLANINOTUM, sp. n.

A closely punctate, black female with flavous markings and the abdomen mainly red. Head constricted and narrow behind eyes; mandibles, palpi, labrum, lateral angles of the apically truncate clypeus, and frontal orbits nearly to the concolorous vertical dot, pale stramineous; frons sparsely and finely punctate; face evenly punctate, centrally elevated and apically discreted. Antennæ centrally white-banded and apically attenuate. Thorax very closely punctate, dull with pronotum, callosity below and an elongate one before radix, flavous; notauli fine: metathorax shagreened, with the broad and undiscreted petiolar area apically transaciculate; areola quadrate, parallel-sided, deplanate and extending to base of metanotum, with weak lateral carinæ and no costulæ; spiracles linear, apophyses obsolete. Scutellum nitidulous, very finely punctate, not margined, clear flavous with its basal third and the postscutellum fulvous. Abdomen elongate and parallel-sided, with anus from base of sixth segment more or less definitely black; postpetiole deplanate, finely and irregularly punctate; gastrocœli transverse and deeply impressed, their intervening space much narrower than central area of postpetiole: terebra black and a little exserted. Legs normal, with hind tarsi slender; indefinitely nigrescent red, with hind coxæ and femora darker; hind coxæ finely punctate beneath, with very large scopulæ. Wings hyaline; radix and tegulæ fulvous, stigma red; areolet pentagonal, as broad as high and somewhat small. Length, 9 mm. ♀ only.—From all species known to me of this genus, to which the pale vertical dots and punctate petiole show that it belongs, it differs in its nearly smooth metanotum with the parallel-sided areola extending to base; the central abdominal segments, also, are more deplanate than is usually the case. A couple of females were received from Algeria about 1849, I believe from Francis Walker.

4. SEXALBATUS Wesm.

A single typical male of this palæarctic species was captured in Abyssinia, probably about Harrar, in 1910.

5. FOSSIFER, sp. n.

A closely punctate, black male with profuse stramineous-white markings, and the abdomen and legs mainly red. Head transverse, short and not strongly constricted posteriorly; stramineous with mandibular apices, a dot at the genal orbits, whole occiput with ocellar region and centre of frons to scrobes, black; frons subglabrous; face and clypeus distinctly punctate, with the centre of latter very conspicuously impressed longitudinally at its apex. Antennæ normal, immaculate. Thorax black with prothoracic margin, prosternum, linear callosities before and beneath radices, a broad mesopleural streak, two discal mesonotal vittæ and apex of metathorax on either side, white; notauli short and deeply impressed; areola cordiform, subglabrous, a little longer than broad, not extending to base, and emitting strong costulæ; spiracles linear, apophyses wanting. Scutellum convex, margined to its centre; stramineous, with base of its carinæ and two dots on postscutellum concolorous. Abdomen red with the basal segment alone black; postpetiole convex, evenly and closely punctate, with no carinæ; gastrocœli deeply impressed, large and broader than the striate intervening space; valvulæ fulvous. Legs normal; dull red; tarsi, hind tibiæ and most of their coxæ black; anterior and disc of hind coxæ whitish; front tibiæ internally pale. Wings normal; tegulæ and stigma black, radix whitish; areolet slightly higher than broad, coalescent above. Length, 11 mm. ♂ only.—At once known by the definite thoracic white markings and by the clypeal fossa.—A couple of males from Uganda: one at Chagwe in the Mabira Forest at some 3500 feet in the middle of July 1911; and the other between the Seziwa River and Kampala at the same altitude towards the end of the following month.

6. MUNDATUS Tosq.

This is probably not an uncommon species in Central East Africa, since I have seen several males, but nothing that I can assign as its female. The peculiarly elongate form and dull red coloration are distinctive; and the punctate postpetiole assigns it to the present genus, though Tosquinet (Mém. Soc. Entom. Belg. v, 1896, p. 31) described the male under *Ichneumon*, in its Wesmaelian sense. The extent of black markings is variable: the thorax is usually black with a flavous pronotal callosity, and the mesonotum, excepting a discal vitta, red; sometimes the flavous is become red; at others the black central mesonotal line is lacking, or the spiracular and dentiparal areæ are also red, with or without the propleuræ. Also all the coxæ and trochanters, or as in the type only the anterior coxæ above, are black.—The specimens from which these details are drawn come from Higo Samula in Abyssinia on 30th October, 1911 (*R. J. Stordy*); Abyssinia, probably about Harrar, in 1910 (Collector ignot.); and one, which considerably extends its known range, from the valley of the Rukuru River between 20th and 27th June, 1910, at 3000 feet, in Nyasaland. Another male, differing solely in its black legs with only the anterior tarsi red and inner side of front tibiæ flavous, was found on the west slopes of Mount Kenya, on the Meru-Nyeri Road at some 7000 feet, about 20th February, 1911.

Ichneumon.

This genus is nowadays used in the sense to which it was restricted by Professor Thomson of Lund (Opusc. Entom., 1893, p. 1911), though the difficult task of assigning to their correct subgenera the very numerous species, that were therein included in the earlier times and have been therein placed by careless authors during the recent ones, is by no means yet completed; and this is as true of Africa as elsewhere, being especially applicable to Tosquinet's descriptions of 1896. In fact, of the fifty kinds still placed here from Africa, such things as *I. intratorius* of Fabricius (1793), *I. apicalis* of Wiedemann (1824), *I. desjardinii* of Brullé (1846), and *I. frontalis* of Guérin (1846: *nec* Fourcroy in 1785) are unrecognizable without reference to the scattered and probably lost types. Hence some synonymy is sure to arise. My own experience goes to show that this genus is but poorly represented in the Ethiopian fauna, and that such forms as occur have usually extended from the somewhat broad distribution of palæarctic kinds throughout the southern Mediterranean shores.

1. RUBRORNATUS Cam.

The male only of this conspicuous insect was brought forward by Cameron (Records of the Albany Museum, i. 1904, p. 141) from the Cape, whence I have not received it; nor, curiously enough, from any central part of the Continent. But about Harrar in Abyssinia it must be of comparatively frequent occurrence, for fully half a dozen were comprised in a small collection there made in 1910; and these males show considerable constancy of markings in respect to the flavous and black, though the peculiarly characteristic brick-red of the basal moiety of the second segment may be half obscured by black as in the southern type, black only narrowly at the sides or so broadly suffused with that colour that the rufescence is traceable only between the deeply impressed gastrocœli. This male is obviously allied to the abundant palæarctic *I. sarcitorius* Linn., which extends to Algeria; and, judging by analogy, I here assign to it the following female:—

A very stout and closely punctate, dark crimson female, with ovate abdomen; central flagellar band, whole scutellum, apices of second and third, and disc of the sixth segments, pale flavous; remainder of abdomen from base of third segment, small apical marks before its pale band on disc and sides or else the whole centre of second segment, flagellar apices, sometimes disc of hind coxæ, and the whole thorax except mesonotum or also except metanotum indefinitely, black. Mesonotum with a very faintly nigrescent longitudinal central vitta; stigma fulvous. Exactly resembling *I. sarcitorius* in both structure and sculpture; identical in those of the metanotum, postpetiole, coxal scopulæ and basal nervure; though a little stouter. Length, ♂ ♀, 11–12 mm.—Of this distinct female I have seen two examples, differing only in the extent of rufescent coloration on the metanotum and second segment, which were respectively captured so far apart as Alaba in Abyssinia on 15th November, 1911, by R. J. Stordy, and Durban in Natal during 1904, by J. P. Cregoe.

CHASMIAS.

The right of this genus to distinction from *Ichneumon* has constantly been a moot point since its erection under the name *Chasmodes* by Wesmael in 1844 (*nec* Cuvier, 1836); it was renamed by Ashmead in 1900. We must, I think, look to the Ethiopian fauna to supply us with a good basis of generic distinction, since less than half a dozen species have yet been described altogether: one of these is from Abyssinia and was discovered by Tosquinet.

1. GLAUCOPTERUS Morl.

This was recently brought forward (Ann. S. African Mus. xv. 1916, p. 365) by me from the Cape; but a second female, differing in nothing but its black mesonotum, anus and hind tibiæ, was captured in Abyssinia, probably about Harrar, during 1910.

2. RUFICAUDATOR, sp. n.

A very strongly elongate and somewhat dull species, with the head except mouth and top of face, base of antennæ beneath, anus from apex of fourth segment and anterior tibiæ, brick-red; centre of flagellum very broadly but indefinitely flavous; scutellum alone stramineous. Head posteriorly as broad as the eyes, with cheeks and temples buccate; frons, the centrally elevated face, and the clypeus evenly and distinctly punctate, apex of the last glabrous and sinuate with its centre conspicuously produced. Thorax cylindrical, with superficial notauli; metathorax closely and evenly punctate with fine carinæ; areola subhexagonal, apically a little constricted, extending to base and emitting costulæ from its centre; spiracles elongate, apophyses wanting. Scutellum subconvex, glabrous, with some punctures. Abdomen linear, narrower than thorax and just double length of head and thorax, dull and very closely punctate, with the postpetiole evenly punctate on either side of its glabrous and nitidulous centre; second segment fully twice as long as broad, with the deeply impressed gastrocœli narrower than their intervening space; fourth and fifth segments discally quadrate; valvulæ red and hardly exserted. Legs not long, tarsi slender; front femora internally and their tarsi also rufescent. Wings subhyaline, with stigma black; areolet as broad as high, not laterally coalescent above; nervelet elongate but evanescent. Length, 18 mm.

♂ only.—The type occurred by the Yala River on the southern edge of the Kakumga Forest at between 4800 and 5300 feet towards the end of May 1911, in British East Africa.

Subtribe **Amblypygini**.

AMBLYTELES.

This genus, as established by Wesmael (Nouv. Mém. Acad. Bruxelles, 1844, p. 111) has, like his *Ichneumon*, been subdivided by Thomson into three genera, of which the typical one is well represented by thirty-seven African species, all from the north or south of the Continent except three: Tosquinet had one from Sierra Leone; Szépligeti described one (Bull. Mus. Paris, 1907, p. 137) from East Africa; and another, captured by the Kilimanjaro Expedition, in 1910, for the synonymy of which *cf.* Roman (Entom. Tidskr. xxxi. 1910, p. 144). *Setanta* Cameron (Ann. Nat. Hist. vii. 1901, p. 483) is already known to be identical with the present genus.

1. SPILOPTERUS, sp. n.

A stout, ferruginous species with the metathorax, mesopleuræ and most of abdomen, black; apex of wings broadly nigrescent. Head posteriorly buccate and broader than the eyes; mandibles stout, punctate, and apically black; cheeks buccate; face and clypeus rugulosely punctate, obsoletely discreted, with the latter laterally elevated and apically truncate; vertex trans-striate and not broad. Antennæ attenuate and hardly darker apically, of ♀ slightly explanate beyond their centre. Thorax dull and coarsely punctate; frenum black; notauli apical and small; pleuræ finely punctate, with the speculum dull; metanotum evenly granulose throughout, with no carinæ, its basal sulcus somewhat deeply impressed, spiracles elongate, and apophyses wanting. Scutellum convex, closely and deeply punctate, laterally strongly carinate to near apex. Abdomen elongate-fusiform and finely punctate with the fourth and following, usually all the dorsal, segments black; postpetiole and anus from base of third segment shagreened, or the former in ♂ shining and smoother; gastrocœli very small; hypopygium extending to apex, terebra very slightly exserted. Legs clear red with the posterior coxæ and centre of their femora more or less broadly black; tarsi and hind tibiæ stout. Wings flavescent with whole apices of the front ones abruptly nigrescent from the recurrent nervure and areolet, which is subcoalescent above; tegulæ and the basally paler stigma fulvous. Length, 12–14 mm. ♂ ♀.—Found in scattered forest on the Nandi Plateau at about 6000 feet during early June 1911; and on the southern foot and slopes of Mount Elgon at 5100–5800 feet between the 8th and 13th of the same month, in British East Africa.

2. AURICOMUS, sp. n.

♂. A handsome, aureo-flavous species with profuse black markings and evenly nigrescent wings. Head short, hardly narrower than the eyes, with the posterior margin subtruncate; face finely, with its centre and clypeus much more coarsely, punctate; mandibles narrow and punctate, labrum exserted, clypeus centrally a little produced; frons longitudinally in the centre and back of head, below the occipital margin, black. Antennæ hardly longer than half the body, stout and attenuate throughout, immaculate orange with the joints short. Thorax closely and finely punctate, with all the pleuræ more sparsely punctate and shining; whole frenum, basal scutellar fovea broadly, propleuræ both above and below the collar, mesopleuræ and -sternum except the radical callosities, an apical line and small mark above coxæ, metathoracic base and petiolar area, black; mesonotum indefinitely nigrescent and discally pubescent, notauli apical; metanotal carinæ entire; areola square, glabrous, glittering and spinately produced basally in the centre; spiracles elongate and apophyses wanting. Scutellum a little convex, shining, finely and not closely punctate. Abdomen dull and very closely punctate with golden pilosity, stronger on the fifth and following segments; second to fifth segments except their apical margin regularly and sides irregularly, and whole venter, black; first segment punctate and, except apically, indefinitely rufescent; gastrocœli shining, narrower than the simple intervening space; second and third ventral segments plicate, the last not centrally produced. Legs somewhat stout and not elongate, with only the lower side of hind coxæ and trochanters partly black; claws simple. Wings evenly infumate throughout; tegulæ and radix flavous, stigma and costa black; areolet broad above and a little produced apically below; radius apically reflexed.—The ♀ differs very slightly in having the sternum, pleuræ, and metathorax immaculate black, as also are the posterior coxæ; but the frons and occiput are pale; coxæ not scopulate. Length, 14 mm. ♂ ♀.—The typical male was found at Nairobi during June or July, 1912, by Dr. A. D. Milne; the only female I have seen is labelled with the MS. and most inappropriate name "*fulgidipennis*, Cam., Type. Uganda," and lacks abdomen.

3. FULVOCAUDATUS Tosq.

This male has not been mentioned since first described from Hadda Galla in Abyssinia by Tosquinet (Mém. Soc. Entom. Belg. v. 1896, p. 76). It is an extremely conspicuous species in its black wings and body with orange antennæ, red head and anus, and fulvous legs. The present example of but 11 mm. is smaller than the type and has the areola as long as broad, distinctly hexagonal, and not "à bords arrondis"; it is from Peter Cameron's collection, simply labelled "Erythria."

flavescent. Length, 13–15 mm. ♂ ♀.—The type was captured at Mlanje on 4th October, 1913, at 2300 feet, in Nyasaland; and the androtype between Jinja and Busia in some forest land east of Busoga on 28th July, 1911, at 4000 feet, in Uganda.

2. UNIPUNCTOR, sp. n.

An elongate black male with profuse whitish markings; the legs and abdomen, except anus, red with segmental apices whitish. Extremely like *S. didymatus* but with the mandibles and palpi black, the frontal and external orbits immaculate; basal two-thirds of flagellum red, pleuræ and mesonotum immaculate; areola finely sculptured and apically stramineous; scutellum convex; basal segment red, the fifth and sixth black, with only their apex whitish, and the fourth basally nigrescent; tegulæ, coxæ and trochanters entirely black; areolet broader and very broad above. Length, 13 mm. ♂ only.—The type was captured at Harrar in Abyssinia, 1912.

3. TRIANGULATOR, sp. n.

A black male with profuse whitish markings; the legs and abdomen red, with segmental apices whitish. Very similar to the last species and differing from *S. didymatus* in the convex scutellum, sculptured metanotal areola, black external orbits and mouth-parts, and in the rufescent flagellum. It is distinct in having the areola remote from metanotal base, and its apex flavous, which colour extends thence obliquely to the obsolete apophyses; the abdomen is not black-marked, and the stigma is black. Length, 9 mm. ♂ only.—The type is from Queenstown in Cape Colony, where it was captured during 1907 by E. T. Wells.

XENOJOPPA.

The discovery of this genus in Africa is as interesting as that of *Lagenesta* and other genera that have hitherto been regarded as purely Oriental; it is even more so, on account of its peculiar specialization, for it is the only one known to me among the Ichneumonides that shares coxal dentition with the Phæogenides. *Xenojoppa* was published by Cameron in 1902 (Entomologist, xxxv. p. 179) upon finding that his original name for the genus, *Magrettia* (Ann. Nat. Hist. vii. 1901, p. 480) had already been employed by Brunner v. Wattenwyl in the latter's 'Monographie der Stenopelmatiden und Gryllacriden' (Verh. z.-b. Ges. Wien, xxxviii. 1888, p. 285). Two species were brought forward by its author (lib. cit. p. 481 et xii. 1903, p. 569); and I have seen a third *; all from Northern India. The following considerably extends its southern range.

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* XENOJOPPA KALI, sp. nov.

A shining and metallic, particoloured species. Head buccate and black, with the inner ocular orbits flavous and most of the mouth rufescent; clypeus not discreted. Antennæ setaceous, not elongate, with the seven central flagellar joints white,

1. FOSSIFRONS, sp. n.

A stout, tricoloured female: head and thorax pale stramineous with occiput through ocellar region and centre of frons to scrobes, antennæ (except a discal central seven-jointed white band), and disc of thorax mainly, black; abdomen and legs clear red with only apices of sixth and seventh segments subnigrescent before the narrowly white anus, and tarsi discally infuscate. Head posteriorly as broad as eyes, with both temples and cheeks buccate; frons depressed throughout, glabrous and glittering, slightly transaciculate below ocelli, with the elevated orbits incurved below ocelli; face and clypeus transverse, not discreted, distinctly and in centre rugosely punctate, with apex of the latter centrally a little concave, not dentate; labrum exserted. Thorax with pleuræ and sternum flavidous; mesonotum shining, sparsely and coarsely punctate, black with elevated callosities before and below radices and two discal vittæ flavous; notauli elongate, fine and subparallel; metathorax dull and punctate-aciculate, with petiolar area strongly concave, centrally stramineous and very long; areola proportionately short, transverse, extending to base, apically concave and laterally rounded, emitting no costulæ; spiracles elongate, dentiparal areæ produced but with no apophyses, externally stramineous. Scutellum slightly convex, very coarsely punctate, laterally finely carinate to the excised apex; flavous with a black longitudinal streak down its centre to near apex; postscutellum flavous. Abdomen closely punctate and dull; basal segment shagreened, with sides of the broad postpetiole distinctly punctate; gastrocœli striate and deeply impressed, broader than the aciculate intervening space; hypopygium extending to apex, terebra black and hardly exserted. Legs normal, anterior paler, claws minute; anterior tarsi subdilated, hind coxæ subacutely dentate on their inner side. Wings hyaline, radix and tegulæ fulvous, costa and stigma black; areolet triangular, coalescent above, distinctly produced externally, broader than high; nervelet, and another in second recurrent, distinct; discoidal cell subparallel, lower basal nervure vertical and very slightly postfurcal. Length, 13 mm. ♀ only.

Thorax cærulescent and metallic, with its disc green and reticulate; notauli wanting; areola small and quadrate, emitting the entire costulæ from near its apex; petiolar area narrow and parallel-sided. Scutellum stramineous and subglabrous, elevated and laterally margined throughout. Abdomen fusiform and brilliant blue with basal segment fulvous, its apex and the apices of the second and fifth to seventh segments pale stramineous; first segment convex and nearly smooth, the second a little dull with longitudinal striation and large gastrocœli; terebra not exserted, its base covered by hypopygium; venter black with the two basal segments white and alone plicate. Legs clear fulvous, with only the anterior coxæ white and hind tarsi black. Wings slightly clouded; stigma black, radix and tegulæ testaceous; cubital nervure, bearing very slight nervelet, straight and subparallel with the anal; areolet not coalesced above, radius apically reflexed. Length, 14 mm. ♀ only.—Extremely distinct from both Cameron's species in its conspicuous coloration, black face, narrower abdomen, and in the straight inner cubital nervure with sessile areolet and apically curved radius. India bor.; Dehra Dun and, I believe, Assam.

—The peculiar prolongation of the elevated frontal orbits below the ocelli is remarkable.—Taken at Entebbe in Uganda between 10th and 20th March, 1914, by C. C. Gowdey.

CTENICHNEUMON.

The third of the subgenera into which Thomson split the Wesmaelian genus *Amblyteles* (Opusc. Entom. xix. 1894, p. 2083). I have already assigned to it one South African species (Ann. S. Afr. Mus. xv. 1916, p. 365); three of the palæarctic kinds that extend to Algeria fall herein; and Dr. Roman has recently shown that the Egyptian *A. tauricus* Kriechb. (Entom. Tidskr. xxxi. 1910, p. 157, ♂ ♀) is also referable to it.

1. CASTANOPYGUS, sp. n.

A slender and somewhat small, black male with the antennæ (except apices), anterior tibiæ and femora, face (except its stramineous orbits) and clypeus, fulvous; and the anus from base of fifth segment, crimson; wings evenly infumate. Head small and transverse, posteriorly obliquely constricted; frons and face subconfluently punctate, clypeus irregularly punctate, short and impressed in centre of its truncate apex; labrum exserted. Thorax immaculate black, closely punctate and not dull; notauli deeply impressed; metathorax convex, with stout carinæ; areola subtriangular, apically truncate, basally constricted and acuminate at postscutellum; spiracles elongate, apophyses wanting. Scutellum deplanate, apically aciculate and laterally carinate to centre. Abdomen sublinear and dull with second segment striate; postpetiole abruptly explanate, closely aciculate, with spiracles prominent and its apical angles punctate; gastrocœli deeply impressed and somewhat large; valvulæ red, extending to apex. Legs slender and black with the front tarsi, tibiæ, and apical half of femora internally, pale; tarsi setiferous. Wings small, infumate throughout; tegulæ and stigma black; areolet exactly pentagonal, broad above; nervelet wanting, lower-basal nervure slightly postfurcal. Length, 11–12 mm. ♂ only.—Closely allied in coloration to *Amblyteles castanopygus* Steph.—Males were taken on the western foot of the Aberdare Mountains, at an altitude of 8300 feet, on 1st March, 1911, in British E. Africa.

Subtribe **Heresiarchini.**

The following genera are here grouped under this subtribe in a somewhat different sense from that intended by its erector in Smith's 'Insects of New Jersey,' 1900, p. 567; though hardly from that of Wesmael when erecting the typical genus *Heresiarches* (Mém. couron. Acad. Belg. 1859, p. 93), since the latter makes no reference to the shape of the face which, on the contrary, is shown (as figured) to be not transverse. Its metathoracic spiracles are linear, and the restriction of the group in my 'British Ichneumons' of 1903 was for local purposes only.

As a matter of fact there appears to be but a single foundation which consists solely of the simple mandibles, ending in a single point or tooth in place of the bidentate apex usual in Ichneumonidæ, to distinguish this group from the Oxypygini; and I do not find that Ashmead's characters (Proc. U.S. Nation. Mus. 1900, p. 12), "Head, viewed from in front, broader than long; occiput strongly concave, the temples broad, full," no repetition of which is made at lib. cit. p. 20, are constant. At all events the following genera all have the face longer than broad and bear facies of Oxypygini, usually with the remote hypopygium of that subtribe. Some local cause for which we are at present unable to account—not improbably peculiar ease of emergence from the host-pupa—has eradicated the lower mandible, and on that account thrown these genera in a sufficiently convenient group, differing in nothing but the mandibular structure from Amblypygini and Oxypygini*. In all other respects *Myermo*, *Chiaglas*, etc., might be considered true *Stenichneumon*-species, while *Fileanta ruficauda* Cam., from India, is almost a true *Amblyteles palliatorius* Grav., from Europe.

Neither Wesmael nor Berthoumieu recognized the present Subtribe; but Schmiedeknecht in 1902 adds to the already known four genera *Myermo*, *Fileanta* and *Setanta* from India, of which I have shown (cf. *Amblyteles* supra) the last to be a mere synonym.

List of Heresiarchid Genera.

Stenodontus Berthoumieu, Ann. Soc. Entom. France, lxv. 1896, p. 346 = *Gnathoxys* Wesmael, Nouv. Mém. Acad. Brux. xviii. 1844, p. 165 (nec Westw. 1842).—Europa, Africa bor.

Heresiarches Wesmael, Mém. couron. Acad. Belg. viii. 1859, p. 93.—Europa.

Rhexidermus Förster, Verh. preuss. Rheinl. xxv. 1868, p. 192 (*species exstat.*).—Europa.

Plagiotrypes Ashmead, Proc. U.S. Nation. Mus. xxiii. 1900, p. 20.—Amer. bor.

Gyrodonta Cameron, Ann. Nat. Hist. vii. 1901, p. 485.—India.

Fileanta Cameron, Ann. Nat. Hist. vii. 1901, p. 525.—India.

Myermo Cameron, Ann. Nat. Hist. vii. 1901, p. 523.—India, Burma.

Miojoppa Cameron, Zeitschr. Hymen. u. Dipt. ii. 1902, p. 391.—India.

Algathia Cameron, Zeitschr. Hymen. u. Dipt. ii. 1902, p. 392.—India, Burma.

Chiaglas Cameron, Ann. Nat. Hist. ix. 1902, p. 152 et l. c. xx. 1907, p. 81.—India.

Nænaria Cameron, Ann. Nat. Hist. xi. 1903, p. 313.—India.

Caspipina Cameron, Trans. Entom. Soc. Lond. 1903, p. 219.—Assam.

Triptognathus Berthoumieu, Genera Insect. xviii. 1904, p. 49.

Macrophatnus Cameron, Rec. Albany Mus. i. 1905, p. 232 et Ann. S. African Mus. v. 1906, p. 175.

Rossella Cameron, Ann. South African Museum, v. 1906, p. 176.—Africa mer.

Allonotus Cameron, Ann. Nat. Hist. xx. 1907, p. 29.—Borneo.

Orthognathella Szépligeti, Faun. S.W. Australiens, i., ix. 1908, p. 320.—Australia.

Heresiarchoides Brethes, Ann. Mus. Buenos Aires, xix. 1909, p. 51.—Argentina.

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* In the European fauna, such things as *Ichneumon rufidens* Wesm. and *Amblyteles uniguttatus* Grav., fall into the present category.

MAGWENGA, gen. nov.

Mandibles unidentate, apically acuminate, not externally sulcate; cheeks and temples elongate and quite straight, not buccate; frons centrally carinate; occiput and juxta-scrobal orbits acutely margined. Flagellum filiform and apically strongly attenuate, its basal joints elongate. Metathoracic spiracles linear and elongate; metanotum with neither carinæ nor areæ, its centre slightly elevated. Scutellum laterally carinate throughout. Postpetiole not at all sculptured, with no apical fovea; gastrocœli large; apex of second segment centrally emarginate; hypopygium remote from anus. All the claws stoutly pectinate. Wings hyaline with a central fascia and apical spot nigrescent.—Nearest to *Caspipina*, but the cheeks are not buccate, the flagellum not compresso-dilated; metanotum excarinate; postpetiole neither basally elevated nor apically foveate; basal nervure not continuous; tarsi pectinate and wings maculate.

1. MACULIPENNIS, sp. n.

A dull black female, with the hind coxæ red; the wings centrally black-banded, with a circular apical spot. Head long, glabrous and sparsely punctate, behind the eyes parallel; clypeus and face deplanate, hardly discreted, with confluent and somewhat close punctures, apex of former truncate and laterally margined; palpi white; cheeks longer than breadth of the white base of mandibles. Antennæ black with their centre, except laterally, white-banded. Thorax stout, convex and closely punctate, discally smooth; notauli obsolete, speculum small and glittering; metathorax discally smooth and shagreened, its base depressed but not sulcate; petiolar area triangular and laterally striate, very small; apophyses wanting. Scutellum large, smooth with a few punctures, broadly margined, with extreme apex aciculate. Abdomen elongate-fusiform, roughly punctate, with anus from fifth segment and the postpetiole glabrous; petiole, or at least its base, red; gastrocœli large and double breadth of their intervening space; terebra hardly exserted. Legs stout; anterior with coxæ, inner side of tibiæ and of their femoral apices, flavidous; hind trochanters and their indefinitely scopulate coxæ bright red; third and fourth hind tarsal joints white. Wings hyaline and not broad; areolet not quite coalescent above, lower basal nervure strongly postfurcal; a central broad infumate band from the basal to centre of the disco-cubital nervures and a round concolorous spot on apex of radius; hind wing also infumate in radial cell. Length, 10–11 mm. ♀ only.—These remarkable females are from 3700 feet at Buddu on the west shores of the Victoria Nyanza, on 19th September; and from 3800 feet to the south-east of Buddu, in the Tero Forest, on 26th September, 1911, in Uganda.

MIOJOPPA.

Head not broader than thorax, roundly constricted posteriorly; temples shorter than eyes; face subdeplanate and not discreted from clypeus; cheeks not short, mandibles gradually constricted to apex, palpi slender and elongate. Antennæ stout and not longer than body, broadly white-banded, and beyond their centre compresso-dilated. Mesopleuræ obliquely carinate above their centre; metathorax gradually and roundly curved, with its lateral carinæ entire; petiolar area parallel-sided, narrow and extending to basal third of metathorax; areola obsolete, incomplete, remote from metanotal base; spiracles suboval and thrice longer than broad; apophyses wanting. Scutellum deplanate, stoutly carinate laterally to near its centre; postscutellum basally bifoveolate. Abdomen with first longer than second segment, and gradually explanate from petiole; second and third segments closely punctate; gastrocœli superficial, longer than broad with the intervening space closely striate; second and third ventral segments plicate; terebral valvulæ exserted, as long as two anal segments. Basal nervure not continuous through median; nervelet indistinct.—I place this genus [of which the above is Cameron's diagnosis (Zeitschr. Hymen. u. Dipt. ii. 1902, p. 391), slightly emended by an examination of the genotype] next the Platyurini, with which the structure of the basal segment is in exact agreement; and I am not sure that it were not better actually merged therein, in spite of the mandibular conformation. The single known species from India was described, loc. cit., incorrectly as female.

1. QUADRILINEOLA, sp. n.

A dull, black and closely punctate male with the legs except basally, antennæ except disc of scape, mandibles except apices, and the palpi fulvous; facial orbits shortly and two facial vittæ, a small callosity before radices, a dot at apical angles of postpetiole, scutellum except extreme base, and the postscutellum flavous. Clypeus apically truncate and a little reflexed; frons and face closely punctate and pale pilose; areola short, semicircular, and apically incomplete; scutellum shining, sparsely punctate, and subconvex; gastrocœli small and valvulæ luteous; coxæ and trochanters black; tarsi simple; areolet very broad above; radius sinuate. Length, 11 mm. ♂ only.—The sculpture and outline are similar to *Cratichneumon annulator* Fab., rather than *Platylabus pedatorius* Fab., both black males of like form and structure; the distribution of the pale marks is peculiar.—The type was taken at Deelfontein in South Africa about 1903 by Col. Sloggett.

Subtribe **Listrodromini.**

NEOTYPUS.

To the two species of this genus, which is likely to find its headquarters in Africa, and was erected by Förster (Verh. pr. Rheinl. 1868, p. 194), that have already been recorded by Kriechbaumer and myself, I can now add a third.

1. OBSCURATOR, sp. n.

A small, dull, black female with the thorax and petiole entirely red. Head transverse and narrow behind eyes; frons closely punctate and apically trans-striate; face finely trans-striate, centrally elevated; clypeus glabrous, broad, uneven, bifoveate, apically emarginate and centrally subreflexed; labrum concealed, mandibles slender and dull testaceous. Antennæ elongate, slender, apically attenuate, with the basal joints elongate and centre white banded. Thorax short and stout, closely and evenly punctate, with deep notauli and dull speculum; petiolar area covering two-thirds of metathorax, discreted, its central area deeply concave and trans-striate; areola proportionately short, transverse-semilunate, not extending to the depressed base, emitting weak costulæ from centre; spiracles oval and oblique, apophyses stout and obtuse. Scutellum red, convex, dull, closely punctate, laterally margined to near apex. Abdomen ovate, dull, very finely punctate; basal segment red and linear, abruptly explanate at the black postpetiole, which is finely punctate-aciculate with its apical angles and those of the second segment white-dotted; gastrocœli very small; apex of fifth segment narrowly, of sixth broadly and whole of seventh, white; terebra black, not exserted. Legs black and not short, the anterior tibiæ and front femora mainly testaceous; coxæ simple, claws pectinate. Wings hyaline, stigma and nervures black; areolet broad above, nervelet distinct, basal nervure continuous through the median. Length, 8 mm. ♀ only.—The type occurred at Mlanje on 26th May, 1913, in Nyasaland.

Subtribus **Platylabini.**

PLATYLABUS.

To my Table of the southern African species of this genus (Ann. S. Afr. Mus. xvii. 8, 1917, p. 201) I am now enabled to add a couple of very distinct species, and the alternate sex of another.

1. ATRICINCTUS, sp. n.

A rufescent-testaceous species with profuse black markings, and the setaceous flagellum pale banded. Head slightly broader than thorax, and but little narrowed behind the strongly prominent eyes; ocelli and mandibular apices alone nigrescent; face and mouth flavidous, the former obsoletely punctate and not discreted from the apically truncate clypeus; labrum exserted, lower mandibular tooth very small. Thorax dull, with the mesonotum shagreened and notauli distinct; petiolar area, postscutellum, and disc of frenum abruptly black; areola as long as broad, basally rounded, emitting fine costulæ from its centre; basal area distinct, spiracles elongate, apophyses wanting. Scutellum dull and somewhat elevated with dark lateral carinæ to near apex. Abdomen cylindrical and dull with base of segments two to five, and centre of the second, black-banded; basal segment smooth, shining and basally whitish; thyridii transverse-linear, with the intervening space very narrow; valvulæ obsolete. Legs slender with apices of the hind coxæ and of their femora nigrescent, of their tibiæ infuscate; hind tarsi stramineous throughout. Wings normal and flavescent, with stigma and tegulæ flavous; areolet as broad as high, subcoalescent above, emitting recurrent from its centre; basal nervure continuous through median. Length, 10 mm. ♂ only.—The black-banded abdomen and metathorax are distinctive.—One male at Fort Portal Road, Mbarara, in Southern Toro, at 4000 feet, on 22nd October, 1911, in Uganda.

2. MEDIORUFUS, sp. n.

A pale testaceous species with sparse black and white markings; thorax tricoloured. Head transverse and abruptly constricted behind the prominent eyes; frons smooth with its base, like the elevated ocelli, black: all the orbits broadly, mouth and face stramineous, the last deplanate and obsoletely punctate, not discreted from the apically truncate clypeus, which is centrally impressed; lower mandibular tooth and the occipital margin strong and nigrescent; ♂ with centre of frons and whole occiput black. Antennæ setaceous, black and a little incrassate beyond their broadly white-banded centre; basal joints rufescent beneath. Thorax dull; mesonotum laterally deep black, which colour is bounded internally by a narrow flavous longitudinal band; elongate callosities before radices clear stramineous, notauli short and deeply impressed; metanotum shining and sparsely punctate; areola cordiform, longer than broad and apically subconstricted, emitting strong costulæ before its centre; petiolar area transaciculate, spiracles elongate, apophyses wanting. Scutellum margined laterally to apex and, like the postscutellum, nitidulous and stramineous. Abdomen dull, discally deplanate, of ♀ elongate-fusiform; the four basal segments closely sculptured, with postpetiole and base of the second centrally aciculate; thyridii triangular, not small and hardly narrower than the intervening space; anus from base of sixth segment, valvulæ and the slightly exserted terebra, black; seventh segment of both sexes discally white; ♂ with disc of third and fourth segments black-marked. Legs slender and normal, with the hind tarsi apically nigrescent and their tibiæ straight. Wings hyaline, tegulæ and stigma testaceous; areolet as broad as high, coalescent above and emitting recurrent slightly beyond its centre; basal nervure continuous. Length, 9–10 mm. ♂ ♀.—The tricoloured mesonotum and anus are remarkable.—The type occurred on 14th July, 1910, at Blantyre, in Nyasaland, to Dr. J. E. S. Old;

the androtype was captured at 6400 feet, on Mount Kokanjero, to the south-west of Elgon, in early August 1911, in Uganda. A rather differently coloured female is labelled simply "Erythria," and shows no structural modifications.

3. CETA Morl.

A female of this species which I brought forward in Ann. S. Afr. Mus. xvii. 8, 1917, p. 203, with the capital disc entirely red, was taken at St. James, in Cape Town, on 24th October, 1911, by K. H. Barnard.

4. VALLATUS Morl.

I was only able to indicate the male of this species (Ann. S. Afr. Mus. xv. 1916, p. 370). The ♀ differs in having the ocelli alone black, the six basal flagellar joints apically subnodulose and the first pale beneath; the stramineous thoracic markings are obsolete and mesonotum totally black; the areola not broader than long; the scutellum is testaceous, postpetiole nigrescent, terebra black and but slightly exserted.

Fort Portal Road, at Mbarara, Southern Toro, at some 4000 feet, on 22nd October; and on the north-west shores of the Victoria Nyanza, at 3800 feet, in the middle of September 1911, in Uganda.

Subtribe **Phæogenini.**

BENECLES.

Head fully as broad as thorax; apex of clypeus broadly and centrally impressed, its sides obliquely sulcate above; mandibles stout and parallel-sided with the upper tooth acute and the lower the shorter; temples small and obliquely constricted. Antennæ longer than body with scape distinctly shorter than basal flagellar joint, which is much longer than the second. Metanotum slightly impressed basally and not produced apically, with complete areæ and no apophyses; areola broader than long and subconstricted towards its truncate and strongly carinate apex; spiracles small and subcircular. Scutellum evenly subconvex and basally carinate on either side; postscutellum stout. Abdomen elongate and exactly parallel-sided from the postpetiole to the exserted terebra; gastrocœli large, oblique, deeply impressed and remote from base; lunulæ large, anus pale-marked, terebra reflexed and sometimes subvertical. Hind legs much longer than the anterior. Areolet pentagonal, constricted above; nervelet wanting; basal nervure continuous through the median; nervellus intercepted far below its centre.

"The small, round metathoracic spiracles refer this genus to the *Phæogenini*. In Ashmead's 'Classification of the Ichneumon Flies' it would come in near *Herpestomus*. Characteristic is the long, sharp pointed apical and indistinct subapical tooth of the mandibles," says Cameron, in erecting this genus (Entom. xxxvi. 1903, p. 260) on a single Indian individual.

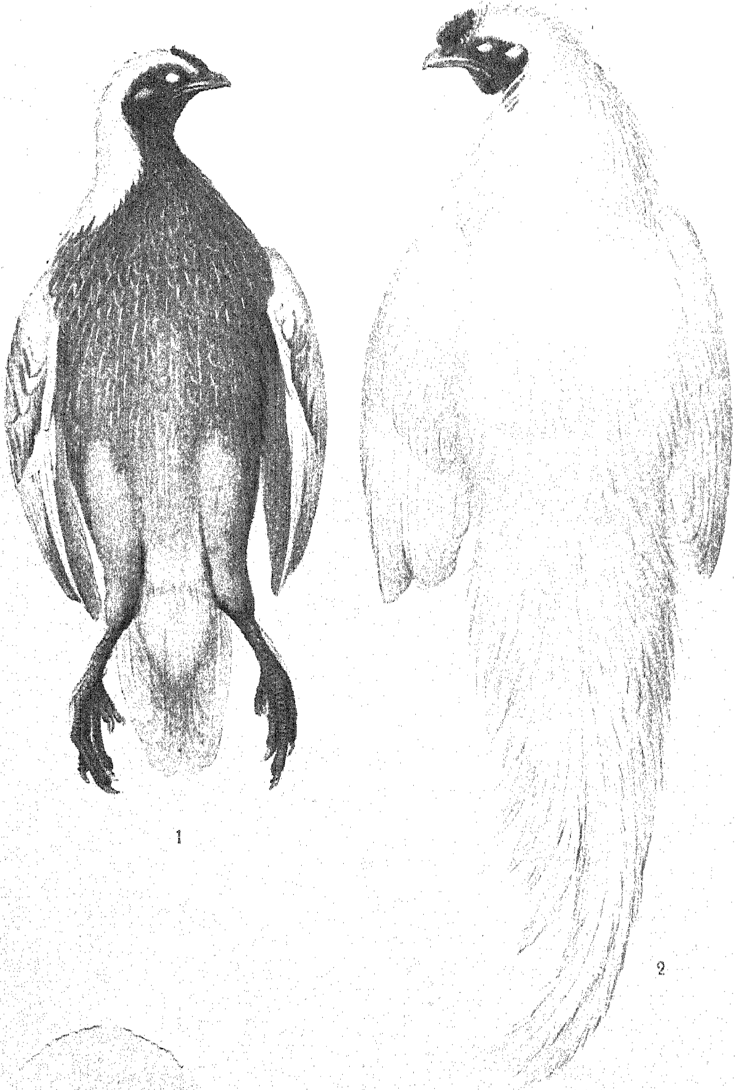
I consider the genotype more remarkable in its large and remote gastrocœli, subcubical head, which is no narrower than the thorax, the reflexed terebra, and the very broad cheeks which are anteriorly hardly narrower than the eyes. In all species the metathoracic spiracles are suboval.

1. DIMIDIATUS, sp. n.

A black species with the thorax and petiole red, anus and trochanters white. Head transverse, deep black, and posteriorly narrow; frontal orbits broadly, and centre of the external ones narrowly, white; face and clypeus black, deplanate, closely punctate, discreted, with the latter broad and apically truncate; palpi white. Antennæ filiform, broadly white-banded with the basal joints rufescent beneath. Thorax cylindrical, dull and brick-red with pronotum white and prosternum nigrescent; mesonotum closely shagreened, with elongate but superficial notauli; metathorax somewhat short, closely punctate; areola as broad as long, apically truncate and basally rounded, emitting distinct central costulæ; basal area entire, the petiolar subvertical and transaciculate; apophyses wanting, spiracles exactly ovate. Scutellum shining, quadrate, sparsely punctate and laterally margined throughout. Abdomen deep black, with the first segment brick-red; three basal segments dull, the first convex and shagreened with prominent lateral tubercles; thyridii transverse-linear, intervening space very narrow; segments five to seven deplanate, quadrate and strongly nitidulous, the seventh white; terebra slender, black, slightly exserted. Legs black with the anterior, except basally, subtestaceous; all trochanters, except apices of hind ones, pure white and calcaria subconcolorous; hind coxæ simple. Wings hyaline and somewhat small; tegulæ and stigma dull ochraceous; areolet pentagonal and not large; basal nervure continuous. Length, 9 mm. ♀.—Certainly allied to the genus *Dicælotus* in its abdominal structure.—Taken at Durban during 1902 by F. Muir, ex coll. D. Sharp.

2. POLITANUS, sp. n.

A black species with most of the thorax and legs testaceous, and the anus white. Very similar to the above species in structure, but with the basal segment black; the whole metanotum with frenum and a central spot at mesonotal apex black; the external orbits broadly, with the face and mouth except longitudinally in the centre, white; the legs are not white-marked and the areola is a little transverse. Length, 7 mm. ♀ only.—Captured at Western Ankole during the middle of October 1911, at between 4500 and 5000 feet, in Uganda. Phæogenini appear rare in Tropical Africa; of the twenty species recorded from the Continent, no more than four are known south of the Sahara, besides those here described.



Bale & Danielsson, Imp.

HYBRID COMMON FOWLS.

12. Results of a Mendelian Experiment on Fowls, including the Production of a Pile Breed. By J. T. CUNNINGHAM, M.A., F.Z.S.

[Received April 29, 1919: Read May 27, 1919.]

(Plate I.*)

In the 'Proceedings' of this Society for 1912 there was published a paper by me under the title "Mendelian Experiments on Fowls," in which I recorded certain results of a cross between a male black-red *Gallus bankiva* and a Silky hen. The object of the present paper is to describe the later generations obtained from this cross, and especially to describe in detail how it produced a "pile" type of colour which bred true. In my former paper I mentioned the fact that the two white cocks of the first brood of the F_2 generation at the age of 4½ months showed a yellowish-orange band of colour across the loins, and the second of them had also some very pale patches on the neck ventrally and above the eye on each side. In April 1916 I exhibited at a meeting of the Zoological Society a number of skins of the fowls bred from this cross, including specimens of the pile birds of both sexes, but hitherto I have not recorded in detail the characters observed in successive generations of the crossed birds, as I propose to do in the present paper.

All the generations were descended from a single pair of the F_1 generation, hatched from the original crossed pair at the Zoological Gardens. To distinguish the generations, broods, and individuals I have adopted the following formulæ: the number indicating the generation is placed below the line after the letter F, it is followed by a Roman numeral indicating which of the successive broods of that generation the bird belongs to, then follows an Arabic numeral indicating the particular bird of the brood, and lastly the symbol of sex. Thus F_4 V 1 ♀ is a hen numbered 1 in the 5th brood of the 4th generation.

In my former paper, which dealt only with the F_2 generation, I pointed out that the only two whites of the first brood showed a trace of colour, whereas the original silky of the crossed pair had no colour. Both these whites were cocks, and F_2 I 1 ♂ showed a band of faint orange-yellow colour across the loins, while F_2 I 2 ♂ showed a similar band, still fainter, together with some very pale patches on the neck ventrally and over each eye. This condition was noted on September 30, the birds having been hatched on May 15 (age 4½ months).

There were two others, both white, in a second brood, date of hatching not recorded. Of these F_2 II 2 ♂ also showed a tinge of yellowish colour across the loins. F_2 II 1 ♀ was given away at an early age, and no pigment on this hen was noted, although, considering that at the time I was not aware of the sexual

* For explanation of the Plate see p. 202.

difference in this pigment, it is not certain that pigment was entirely absent.

My view concerning this trace of pigment in otherwise white recessives was that the segregation of the colour-character was not complete, but that a trace of the pigment-character passed over to the recessives. If this happened at every generation the amount of pigment should increase, and in order to test this I mated the slightly pigmented recessive with a coloured dominant bird. The birds of F_2 were mated thus:

(1) F_2 I 1 ♂ white × F_2 I 6 ♀ coloured and
F_2 I 8 ♀ coloured.
(2) F_2 I 2 ♂ white × F_2 I 7 ♀ coloured.

The two females of the first mating both had light-coloured heads, while No. 7 in the second mating had a black-coloured head. This is an individual difference in the colour of the dominants which is further discussed below.

F_3 I was from the second mating shown above, and consisted of four chicks hatched, three "white" or recessive, one coloured. This, of course, shows that the hen parent was heterozygous for colour, as if she had been a pure dominant all the chicks would have been coloured. In this brood I noticed for the first time a peculiarity of the recessive chicks in the down stage. The coloured chicks, as in other black-red breeds, are longitudinally striped: a broad dark stripe runs along the mid-dorsal line, and on each side is a narrower dark lateral stripe which on the head passes through the eye, the intermediate parts and ventral down being of a lighter brown. In the recessive chicks there are *white* bands where the darker bands occur in the coloured chicks, and yellow down on the rest of the body. As will be seen later, this agrees with the "pile" character in the fledged and adult birds.

The first brood of F_3, hatched May 13, were carefully examined on June 23, when they were 6 weeks old and nearly fledged. All three recessives had colour on the throat and breast, but in different degrees: No. 2 had most colour, not only brown colour quite distinct but *also black feathers* here and there; No. 3 had less colour, and No. 4 least. At this date there was no colour on the back.

F_3 II, hatched about May 23, 1912, consisted of 5 chicks, 4 coloured, 1 "white" or recessive. This last showed very slight but distinct colour on the throat on June 29, when 5 weeks old, and no colour on the back. As in Brood I, at 6 weeks of age, this is the condition when the chicks are first fledged, when they have developed the first adult plumage.

In brood F_3 III, hatched May 28, there were 11 chicks, 6 coloured and 5 white. Of the latter, all except No. 7 showed some brown on throat and breast on July 17, when they were 7 weeks old. A slight but distinct trace was afterwards seen on the throat of No. 7.

At this time I knew nothing about the colour-characters of pile fowls, and did not suspect that sex had an important influence on the development of the small amount of colour which I was observing on the white or recessive chicks. In the second generation F_2 I 1 & 2 were both males, and I made a note that the colour on the back of these seemed to get a little deeper as they grew older. F_2 II 1 was a white female and F_2 II 2 a white male. The former was given away at an early age without any record being made of the presence of colour on its breast; F_2 II 2 was killed on November 8, 1912, when it was about 5 months old, and it is recorded in my notes that it had a tinge of yellow over the back (which includes the dorsal part of the folded wings), but that the colour was very slight.

In the three broods of F_3 above described the two whites of the first brood were both males, the single white of the second brood was also male, of the five whites in the third brood F_3 III 7, 8, & 11 were males, 9 & 10 females. On August 25 I first observed with certainty that in the males the colour disappeared on the throat and breast as it developed on the back and loins, while in the females it continued to increase somewhat both in depth and extent on the throat and breast. At this date in F_3 I 2♂ the brownish colour was much diminished on the breast, and there was quite a deep buff on the back and shoulders. In F_3 I 3♂ the colour on the back was not so deep. F_3 I 4♂ was killed on July 23, its skin was preserved, and is still in my possession showing a narrow band of rather deep brown extending from the throat to the breast, and scarcely any yellow on the back. At this date this brood was 3½ months old, and, as I found the young fowls were sexually mature at 5 months of age, it is evident that this change of colour in the cocks from the breast to the back takes place at puberty, while before that time, in the first adult plumage, the cocks resemble the hens. On the same date the only white in the second brood, F_3 II 5♂, had slight brown on throat and breast, rather deep buff on back and shoulders. In the third brood which, of course, was younger, the cocks showed colour coming on back, and a little still on the breast, except No. 7, which had least colour of all the five whites. The hens 9 & 10 had brown on throat and no colour on back. In August of the following year I recorded in my notes the fact that of the surviving white, *i. e.*, piles of this generation, the two cocks, F_3 I 2 & 3, had buff colour on the loins but no colour on the breast, while the hens, F_3 II 9 & 10, had brown on the breast, but no colour on back or loins. Two further points are to be noticed in F_3, (*a*) that the amount of colour in the recessives for plumage colour varies in the individuals though present in all, (*b*) that the maximum amount of colour is distinctly greater than in F_2. The total number of F_3 chicks hatched was 23, 11 pile, 12 coloured.

F_4, 1913, and F_5, 1914.

The first brood of this generation was hatched April 11, but all the yellow chicks in it died in the first week, so there were no recessives in plumage-colour among the survivors. The parents of the second brood were F_3 I 2 & 3 ♂ × F_3 II 2 & 4 ♀, the cocks recessive, the females coloured. As the coloured hens were known to be heterozygous for plumage-colour, it does not much matter for this character which of the cocks or hens were parents of individual chicks. F_4 II 5 was recessive male, F_4 II 6 & 7 recessive females. These all had some brown on the throat in the first mature plumage in different degrees, most in F_4 II 5, in which it was considerable. There were seven chicks in the brood, the other four being coloured, but Nos. 1 & 2 died in the first week. No. 3, a cock, had plumage of remarkably rich colour, a port-wine red on the saddle and shoulders, rich orange neck and saddle-hackles, a deep glossy black on breast and tail.

Altogether nine broods were hatched in F_4, the parents in each case being one pile and one coloured. Of these F_4's, 16 were pile and 25 coloured, a proportion not approaching very closely to the equality expected on the Mendelian theory. All the piles or recessives had more or less colour on throat or throat and breast, some only a little, while F_4 V 1 ♀, hatched June 13, had in July, when about 5 weeks old, deep and continuous brown on throat and breast and extending in traces over the whole ventral surface. The mother of this one was F_3 III 9 ♀, which had, at any rate when examined the previous year, only a little brown on throat. In the hens the amount of brown usually increases somewhat as they grow older.

The birds of F_4 kept for breeding were :—

F_4 II 3 ♂, coloured—very richly coloured.
F_4 II 5 ♂, pile.
F_4 IV 3 ♀, coloured.
F_4 V 1 ♀, pile—much brown on breast and abdomen.
F_4 VIII 6 ♀, coloured, silky.
F_4 VIII 7 ♂, coloured, silky.
F_4 VIII 8 ♂, coloured normal.

Seven broods were hatched from these, forming the F_5 generation. Of these, F_5 III, F_5 IV, and F_5 V were offspring of parents similar in colour. The parents of F_5 IV were F_4 II 5 ♂ pile and F_4 VIII 4 ♀ pile. This mating was made to ascertain if any segregation took place between the brown and the white of the pile when they were bred together. Eight chicks were hatched and they were all pile. There were four cocks and four hens, and in the sexually immature condition, after they were fledged, all had more or less brown on the breast, though the amount of colour varied from "considerable" in F_5 IV 3 ♂ to very slight in F_5 IV 7 & 8, both ♀. This shows, I think, that the piles breed true, that there is no segregation between the brown and white.

The four broods—F_5 I, F_5 II, F_5 VI, and F_5 VII—were offspring of matings of pile with coloured as in previous generations, all the coloured being heterozygous and carrying pile. The total number of chicks in these four broods was 26, of which 12 were pile and 14 coloured. In Broods I & II only one chick survived to maturity in each, and that in Brood I was coloured. F_5 II 3 ♀ was a hen with much brown on breast. The male parent of F_5 II, namely F_4 VIII 2 ♂, had also, before the sexual change of colour took place, much brown on breast. In the piles of the other two broods there was brown on the breast of the hen or yellow on the back of the cocks in all cases, but no very distinct evidence of increase over the previous generation. Owing to my visit to Australia in 1914, I was not able to examine these two broods for colour till they were three or four months old, when the males were already losing the colour on the breast and developing it on the back, and the colour on the back is never more than light yellow, while in the hens it is a much deeper brown on the breast.

F_5 III was the offspring of F_4 VIII 6 ♀ and F_4 VIII 7 ♂, both dark-coloured birds with silky plumage. As these were both heterozygous for plumage-colour there were some piles among the offspring, the numbers being 5 coloured and 3 recessive. Of the latter one died in the down stage, and the other two were both males which had brown on the breast when first fledged. F_5 V was the offspring of F_4 VIII 8 ♂ × F_4 IV 3 ♀, both coloured. Only one F_5 V 7 was pile, and this when first fledged had moderate brown on the breast.

The birds kept from F_5 for breeding again were :—

F_5 II 3 ♀, pile with much brown on breast.
F_5 V 5 ♂, coloured.
F_5 III 1 & 2 ♀, dark silky.
F_5 VI 1 ♂, coloured, dark.
F_5 VII 1 ♂, coloured.
F_5 V 2 & 4 ♀, coloured, light.
F_5 IV 3 ♀, pile with brown on breast.
F_5 VI 2 ♀, coloured dark.
F_5 VI 3 ♀, coloured light.
F_5 V 7 ♂, pile.
F_5 V 6 ♀, coloured light, silky.

F_6 *Generation*, 1915.

In the F_6 generation eleven broods were hatched. Of these six were from matings of pile with coloured, and of the chicks produced by these 24 were coloured and only 9 pile. This is very far from the expectation of equality, and the difference is greater than in F_4 or F_5. In F_6 several of the broods were small, as though fertility had decreased, and it is possible that more of the recessives were either unfertilized or died before hatching. In all these piles of F_6 as well as in those produced by matings of heterozygous coloured birds together, brown colour was present on the breast in the first feathering, disappearing in the cocks as it developed on the saddle. I have no record that any general increase in the pigmentation was noticed, but on the other hand no individuals are noted as having slight or very slight colour on the breast; the records in my notes are either simply brown on breast, or brown on breast moderate.

The Pile Coloration in Fowls.

I think the above evidence is sufficient to show that the recessives from this cross of Black-red with White Silky were not pure white, but developed in 6 generations into Pile fowls. The Pile, a word which is probably related to pied and magpie, is described by Mr. John Douglas, in Lewis Wright's 'Book of Poultry,' 1885, as a variety of Game-fowls. According to the description, it is white where a Black-red is black: neck and saddle-hackles light chestnut-red, back chestnut and claret-colour, shoulder covert and bow of the wings rich claret-red, breast white or laced with pale chestnut, abdomen and thighs white, tail white or with a slight tick of black on the sickles. This applies to the cock; in the hen the head is light golden chestnut, breast a rich chestnut right up to the throat, thighs almost pure white, hackles white faced with yellow-chestnut, back creamy white with a shade of gold, tail white.

The word chestnut here evidently means much the same colour as I have called brown, which on my birds is a light reddish brown. Nothing is said in the description about the immature cocks having brown breasts, while in the adult the breast is white, but this is naturally to be expected considering that the pile is the absence of black. In the cock of black-red fowls the breast and tail are black; in the hen the black is chiefly on the back, head, and tail, and almost absent on the breast and abdomen. Before sexual maturity the cock in its first plumage naturally resembles the hen. At the same time it is to be noted that in Mr. Douglas's description black is not entirely absent from the pile, and it was not entirely absent from those which I bred, an occasional black feather or one partially black having been very frequently observed.

Mr. Douglas remarks that Piles breed true to colour, as I have shown was the case in my experiments, but that now and then a cross of the black-red is thrown in to give hardness of feather, after which every black-red produced from the cross should be destroyed. This seemed to imply that the pile was dominant and that when they were bred together after the cross they produced dominant piles and recessive black-reds. As this was so contrary to my own experiments, I wrote to Mr. F. Smalley of Silverdale, Lancashire, an experienced breeder of Game-fowls and well acquainted with Mendelism, who very kindly answered my questions. He informed me that Pile is quite dominant to Black-red so far as Game-fowls are concerned, whether the cross be made with the Pile male or Pile female. Mr. Smalley also stated that according to theory Pile first came from crossing Black-red with white, but that such a cross cannot now be made because there are now no pure white Game, all our whites being "sports" from Brown-reds, which bred *inter se*, always breed white, but which if put to any other colour would at once produce "colour" and most likely that colour would be Pile.

We have now to consider the theory or explanation of the origin of the Pile coloration. My experiments show that a recessive pile is produced by crossing recessive White Silky with dominant Black-red, and it therefore seems probable that a dominant Pile would be produced by crossing dominant white with Black-red, or perhaps other colour. Such crosses I have not yet tried, but hope to do so in future. With regard to my recessive Pile it would seem that the simplest explanation is that segregation is not complete or perfect, but that the chromosomes of the white parent, originally without any colour factor, in the segregation of gametes in the heterozygote take with them some of the substance of the colour-bearing chromosomes, and so cause the development of colour. It must be remembered that the Black-red itself is pied: that is to say, in the cocks the black and red are in separate areas, almost completely exclusive of one another; although in the hens these colours are more mingled, but with reddish brown preponderating on the breast and abdomen. The black segregates more completely than the red, but not quite completely, since there are black feathers or traces of black in the Piles. It is impossible to suggest that the black is dominant and the red recessive, for in that case the F_1 would be black and white pied. The recessive pile then, having a certain amount of dominant red or reddish brown with recessive white, might be expected to segregate, and the effects of such segregation would be visible when the piles were bred *inter se*. That such a segregation does not occur completely is shown by the fact that all the offspring produced by pile × pile have some amount of colour, but the fact that this amount of colour varies in the individuals may indicate that a varying degree of segregation occurs, and probably by selective mating a pure white could be again produced.

The fact, however, demonstrated in the experiments of Bateson and Punnett* that when the Silky is crossed with a certain other recessive white, completely coloured black-red birds are produced in F_1 just as crossing of two white races of Sweet Pea may produce completely coloured flowers, suggests that the origin of the recessive pile in my experiments may require a more complicated explanation. According to Bateson, the colour must be due to two factors X and Y, and when either of these is absent the bird is white. In the case of the two recessive whites producing colour when mated, one has one colour-factor absent, the other the other, so that when fertilization takes place the two factors X, Y are both present and fully developed colour results.

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* Bateson, 'Mendel's Principles of Heredity,' 1909, p. 103.

The absent factors being represented by small letters, one of the white parents is Xy, the other xY, or, rather, these symbols represent the constitution of the gametes, the parent birds themselves must be XXyy or xxYY. The Silky in my experiment then must contain one factor for colour and its gametes must be, say, Xy. The Black-red, on the other hand, must contain both colour-factors, and its constitution must be XXYY and its gametes must be XY. The F_1, then, with colour dominant will be XXYy, and the gametes of this will be XY, Xy. The fertilizations in F_2 will therefore be XYXY, XYXy and XyXy.

The result, it will be seen, is much the same as if the colour was due to a single factor, the first combination giving pure dominants, the second dominant (*i.e.*, coloured) birds carrying recessive white, and the third recessive white like the original Silky. The hypothesis of two colour-factors and the presence of one of them in the Silky thus in no way helps to explain the appearance of the pile-colour in the later generations of my cross: whether there is one colour-factor or two, the appearance of colour in the recessive could not occur if segregation were complete, as Mendelians assume it to be. Segregation would result in the recessive in F_2 or any other generation having a total absence of one colour-factor, whether X or Y, and the occurrence of the colour in the pile shows that some portion of the missing colour-factor has passed from the dominant to the recessive—in other words, has not been completely segregated.

Differences in the Coloured Birds.

Although the production of the pile coloration is the most important of the results of this cross which I have to record, I propose to discuss peculiarities in the heredity of other characters and consider how far they depart from expectation according to Mendelian theory. One of these consists of variations in the depth of colour in the coloured dominants. These variations did not form a continuous series, but divided themselves into two distinct types—a dark and a light. I noticed this first in some of the coloured birds of F_2, where F_2 I 6 & 8 ♀ are noted as having light-coloured heads, F_2 I 7 as having a black head. In later generations I noticed the whole plumage of hens with black head was darker than in those with light head, but I found it difficult to distinguish the two types in the cocks when adult, though it was evident enough in the first mature plumage in both sexes. In F_4 IX, the parents of which were F_3 I 1 ♂ coloured × F_3 III 10 ♀ pile, there were 5 coloured birds to one white, and all the coloured were of the lighter type, but whether the male parent was of this type was not noted.

I tried to acertain whether the lighter type was recessive to the darker. The parents of F_5 III were both dark silky, and of the 5 coloured birds in this brood two were of the darker type with black crests, two were light, and one was intermediate in general colour, but without the black crest. The parents of F_5 V were both of the light-coloured type, and the brood consisted of 6 coloured birds and one pile. The 6 coloured were all of the light type, the character showing in the chicks in the down as well as in the mature plumage. In both these broods there were recessive piles, 3 in F_5 III, 1 in F_5 V. Therefore the parents must have been carrying the recessive white or pile, and in the parents of F_5 III there was segregation not only between colour and pile, but between light and dark colour. The brood F_5 VI was the offspring of F_4 V 1 ♀ pile and F_4 VIII 7 ♂ dark silky. In this brood there were five coloured birds and four pile. Of the former two were accidentally killed during my absence from home, so that I was unable to examine their characters, one was a male, concerning which there is no entry in my notes to show whether it was of the light or dark type, one was a dark female with black head, and one was a female of the light-coloured type. It is evident therefore that in this case segregation of light and dark took place in the coloured male parent when mated with the recessive pile—in other words, the dark type was carrying the recessive light colour, as well as the recessive pile. On the other hand, F_6 VII and F_6 X are broods in which a light-coloured parent (female in one case, male in the other) mated with pile produced only the light type in the coloured offspring.

We may conclude, then, that in the dark type segregation may take place, while the lighter type is recessive and breeds true. Whether the original black-red cock of this cross was heterozygous with respect to darkness of colour, or the lighter type arose *de novo* from the dark type, is another question. Mendelians would, of course, assume that the light type was a unit or factor which always existed, as they do not admit the origin of new factors, but their assumption seems to me unjustified. The facts as described in my experiments may be explained on Mendelian principles by the hypothesis of epistatic and hypostatic factors as applied by Bateson to the colours of mice*. We may assume that in the dark-coloured type there is a factor, D, which causes the development of the dark colour and is absent in the light type. If we write D for the factor which determines the darker colour and C for that which determines colour as distinguished from absence of colour, using as usual the small letters for the absence of these factors, then a dark-coloured bird carrying both light colour and white (or pile) may be represented as

DdCc and the pile as ddcc.

The gametes of the dark bird will be

DC, dC, Dc, dc, while those of the recessive will be all dc.

The fertilizations will be

DC dc..................... dark-coloured offspring.
dC dc..................... light ,, ,,
Dc dc..................... recessive white or pile.
dc dc..................... ,, ,,

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* 'Mendel's Principles of Heredity,' 1909, p. 78.

All this is, of course, regardless of the hypothesis that the colour in itself is due to two separate factors, X & Y. The third of the above fertilizations implies that the factor for darkness might be carried by the recessive without the factor for colour. If so, light-coloured birds mated with pile might produce dark-coloured offspring. I have not observed such cases in my results. On the other hand, another possibility is perhaps worth considering—namely, that the factor determining the darker colour is only quantitatively different from that causing the lighter. The darker colour *may* be due to an additional colour-factor segregating separately. Thus, if we substitute Cc for Dd in the above scheme, we shall have as the offspring of a dark-coloured bird mated with recessive, CCcc, 2 Cccc, cccc—in other words, dark, light, and recessive in the proportions 1, 2, 1 instead of 1, 1, 2. Which of these agrees better with the actual results of experiment, the numbers reared by me were too small to decide.

Pigmentation of Skin.

In my previous paper I described the occurrence of a certain amount of pigmentation in the skin and internal membranes of one of the birds otherwise recessive for this character—namely, F_2 II 2 ♂. In subsequent generations this impurity of the recessives with respect to this character was constantly observed, the amount of pigmentation varying in different individuals, in some cases being greater than in the F_2 generation. Thus, in F_3 IV 2 ♀, which died on October 14th when about 5 weeks old, the skin of the abdomen was dark, almost black, lighter over sternum, dark again over crop and ventral side of neck. There was a good deal of pigment round the eye and on lower eyelid. The shoulder-joint, elbow-joint, and wrist-joint appeared almost black on dorsal side, and the bones of the leg and wing were dark. Slight pigment was visible in the peritoneum over the gizzard, but none in or on the ovary.

In F_4 I, of six chicks five were recessive in skin-pigmentation and one pigmented. In all the recessives there was pigment in the skin of the abdomen and round the eye. F_3 IV 1 ♀ and F_4 IV 2 ♀ were killed in September, 1913, and I skinned them after cutting the feathers short to show the surface of the skin, but the dry skins now do not show the pigment distinctly, as it was in the fresh state. I noted from the examination of F_4 IV 2 ♀ immediately after death that the abdomen was quite dark, and that the pigment was not only in the skin and peritoneum but in the connective tissue of the abdominal wall. There was pigment over the gizzard, the oviduct on the left and the vestigial right oviduct were conspicuously black, and also the ureters appeared as black streaks.

In the later generations all the recessives had pigment in the abdomen. It is clear that in this character, as in that of plumage-colour, pure recessives and therefore complete segregation did not occur, and also that although individuals varied the amount of skin-pigment in some cases increased. Conversely, it was noticed in some cases that the amount of pigment in heterozygous individuals was diminished—for example, F_5 VII 1 ♂ was pigmented like all the rest of that brood, but when killed and plucked in August the following year the breast and back were scarcely darker than in a recessive. Both the parents of F_5 were pigmented, but if one of them were a heterozygous dominant, half the offspring would also be heterozygous, and this was probably the condition of F_5 VII 1 ♂.

Structural Characters.

The three characters hitherto considered are colour-characters due to pigment in the plumage or in the skin and connective tissue. I have now briefly to review the structural characters, of which there are five—namely, silky plumage *versus* normal, comb, crest, feathering of legs, double hallux.

In the 10 birds of F_2 generation there were three with silky plumage and seven normal, in the first brood the numbers were two silky to six normal, the proper proportion of one recessive to three dominant. In F_3, 23 birds altogether, all were normal, although one parent of some of the broods was silky—the other must therefore have been pure dominant. In later generations recessive silkies were again obtained. In two silkies of F_4 V, I thought the silky character was not perfect, the proximal parts of the large wing-feathers being as in normal plumage, and only the ends loose-barbed. But I was not able to make a careful comparison with the pure silky, so that I have no distinct evidence of imperfect segregation in this character, and in any case it would be difficult to be certain about a slight degree of the normal character in silky plumage.

In my previous paper I suggested that the form of the posterior end of the rose-comb was connected with the presence or absence of the crest, and accordingly these two characters may here be considered together. I stated in the previous paper that when the crest is present and large the posterior end of the rose-comb is truncated and trifid. F_3 III 11 ♂ seemed to contradict this rule, for it had a rose-comb pointed behind together with a crest. But in this case the crest was slight, and the point behind was not so perfect as in cases where the crest is absent. F_3 IV 1 ♀ was another similar case, the rose-comb being pointed behind and the crest very slight. In subsequent generations many cases occurred in which the crest was absent, and these must, of course, be regarded as pure recessives.

But the crest, when present, showed great variation in size and development, noted by me as very slight, moderate, and full. It may be assumed by Mendelians that the full crests are pure dominants and the lower degrees are variations in heterozygotes. I was unable to investigate this by breeding specially the individuals with minimum amount of crest, either with one another or with those without crest (recessives). The great variation in size of crest is, however, a fact worth recording, and is anything but simple dominance in the heterozygote. The single combs I obtained appeared to be pure recessives, but there were scarcely any singles in the later generations.

Similar remarks apply to leg-feathering. There are many cases of total absence, and these may be regarded as pure recessives. But, again, there are individual variations, such as very slight, slight, moderate, and complete. There are also three cases, F_2 I 5 ♂, F_5 III 2 ♀, and F_5 IV 1 ♂, in which there was only an infinitesimal trace of feathering on the legs. The parents of the last both had "clean" legs, *i. e.* no leg-feathering at all, and all the others of F_5 IV were destitute of feathers on the legs. The case is interesting as showing that a very minute degree of a dominant character may appear in the offspring of two recessives. In previous experiments with Japanese Long-tailed fowls I noticed a similar minute trace of feathers in chicks of this breed, which normally has no feathers on the legs. These facts tend to support the view that minute degrees of a character may occur in individuals which are not heterozygous, and that such a character as complete leg-feathering is not necessarily an indivisible unit.

The irregularity of dominance in the double hallux was mentioned in my previous paper. The later generations show that the heredity of this character is so irregular that it is impossible to distinguish the recessive from the heterozygote. The parents of F_3 III, for example, both had normal toes on both feet, and of the eleven chicks ten had normal toes and one had the double hallux on both feet. It is evident that one or both of the parents was heterozygous for this character with the normal character dominant. If the chick with double hallux is a recessive, both of the parents must have been heterozygous, and in that case the number of recessives should have been 1 : 3 instead of 1 : 10.

The parent of F_1 I and of F_1 II all had normal toes, yet in the former brood two out of six had the double hallux, in the latter all seven had normal toes. The female parent of F_3 VI had a double hallux on both feet, the male parent had normal toes, and six of the seven surviving chicks had a double hallux on both feet, but in one of them the hallux was only slightly cleft, and in the 7th the hallux was double only on the left foot. This case would agree with theory if the double hallux in the one parent was a pure dominant and the normal feet in the other pure recessive. In other cases it is impossible to tell whether a normal is pure recessive or heterozygous. In several cases both parents with normal toes give chicks all normal, *e. g.* F_4 VIII, F_5 IV, F_5 V, F_6 XI; yet F_5 III, the parents of which were both from F_4 VIII. produced three chicks with normal toes to four with the double hallux. It would seem not merely that the normal may be dominant, but that segregation sometimes occurs and sometimes does not.

1911. F_2 I. Parents F_1 ♂ × F_1 ♀.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest*
1 ♂.	White.	Normal.	Rose.	Black.	Normal.	Much feathered.	None.
2 ♂.	White.	Silky.	Rose.	Normal.	Double hallux on both feet.	Moderately feathered.	Slight.
3 ♂.	Coloured.	Silky.	Rose.	Black.	Normal.	Moderately feathered.	Crest.
4 ♂.	Coloured.	Normal.	Rose.	Normal.	Normal.	Moderate.	Crest.
5 ♂.	Coloured.	Normal.	Single.	Black.	Normal.	A trace.	Slight.
6 ♀.	Coloured.	Normal.	Single.	Black.	Normal.	Moderate.	Present.
7 ♀.	Coloured.	Normal.	Rose.	Black	Normal.	Moderate.	None.
8 ♀.	Coloured.	Normal.	Single.	Black.	Normal.	Moderate.	Present.

F_2 II.

1 ♀.	White.	Normal.	Rose.	Black.	Normal.	Complete.	Present.
2 ♂.	White.	Silky.	Rose.	Normal.	Normal.	None.	Present.

Both Nos. 1 & 2 were males and both on Sept. 30 showed a band of light fawn colour across the back. *Vide* P. Z. S. 1912.

1912. F_3 I. Parents F_2 I 2 ♂ × F_2 I 7 ♀.

Hatched May 1912.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1 ♂.	Coloured.	Normal.	Rose.	Black.	Double hallux on left.	None.	Present.	Two or three minute feathers on outer side of leg.
2 ♂.	White.	Normal.	Rose.	Black.	Normal.	Complete.	None.	Brown feathers coming on throat; this one with most colour on breast and most black on head.
3 ♂.	White.	Normal.	Rose.	Black.	Normal.	Complete.	Present.	2nd degree of colour on breast.
4 ♂.	White.	Normal.	Rose.	Black.	Normal.	None.	Present.	Less brown on throat.
				F_3 II. Parents F_2 I 1 ♂ × F_2 I 6 ♀.				
1 ♂.	Coloured.	Normal.	Single.	Black.	Normal.	Complete.	Present.	
2 ♀.	Coloured.	Normal.	Single.	Black.	Normal.	Complete.	Present.	
3 ♂.	Coloured.	Normal.	Single.	Black.	Normal.	Complete.	None.	
4 ♀.	Coloured.	Normal.	Single.	Black.	Normal.	Complete.	Very slight.	
5 ♂.	White.	Normal.	Rose.	Black.	Normal.	Complete.	None.	Buff colour on throat very slight, none on back June 29, some on back Aug. 4.

1912. F_3 III. Parents F_2 I 1 ♂ × F_2 I 8 ♀.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1 ♀.	Coloured.	Normal.	Single.	Black.	Normal.	Complete.	Present.	Black comb, full crest.
2 ♀.	Coloured.	Normal.	Rose.	Black.	Normal.	Complete.	None.	
4 ♂.	Coloured grey.	Normal.	Single.	Black.	Normal.	Complete.	Slight.	Black crest.
5 ♂.	Coloured grey.	Normal.	Rose.	Black.	Normal.	Complete.	None.	
6 ♂.	Coloured grey.	Normal.	Rose.	Black.	Normal.	Complete.	Present.	
7 ♂.	White.	Normal.	Rose.	Black.	Normal.	Complete.	None.	Infinitesimal traces of colour on breast, seems coming on back.
8 ♂.	White.	Normal.	Rose.	Black.	Normal.	Complete.	Present.	Fair and buff on throat.
9 ♀.	White.	Normal.	Rose.	Black.	Double hallux on both feet.	Complete.	None.	Very little buff on throat.
10 ♀.	White.	Normal.	Rose.	Black.	Normal.	Complete.	None.	Narrow comb. Little buff on throat.
11 ♂.	White.	Normal.	Rose.	Black.	Normal.	Complete.	Present.	Little buff on throat.

F_3 IV. Parents F_2 I 2 ♂ × F_2 I 8 ♀.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1 ♀.	Coloured.	Normal.	Rose pointed.	Recessive.	Normal.	Slight.	Very slight.	Killed Sept. 14, 1913.
2 ♀.	White.	......	......	Recessive.				
3 ♀.	White.	Normal.	Rose pointed.	Black.	Normal.	Slight.	None.	Killed Mar. 24. 1913.

1913. F$_4$ I. Parents F$_3$ I 2 ♂ × F$_3$ IV 1 ♀.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1	Coloured.	......	Rose.	Unpigmented.	Normal.	None.	......	Died first week. Some pigment in skin of abdomen.
2	Coloured.	......	Rose.	Unpigmented.	Double hallux on both feet.	Complete.	......	Died first week. Considerable pigment in skin of abdomen and round eyes.
3	Buff chick, dark at side of head and body.	......	Rose.	Pigmented, but lighter than silky.	Normal.	Complete.	......	Died first week.
4	Yellow a little lighter than 3.	......	Rose.	Unpigmented.	Normal.	Complete.	......	Died first week. Pigment on abdomen and round eye.
5 ♀.	Coloured, dark in down.	Normal.	Rose, trifid.	Unpigmented.	Double hallux left foot.	Complete.	Crest rather full.	Dark head, black crest, pigment on abdomen.
6 ♀.	Coloured, light in down.	Normal.	Rose, trifid.	Unpigmented.	Normal.	Very slight.	Crest moderate.	Plumage June 10 brown; head brown.
F$_4$ II. Parents F$_3$ I 2 or 3 ♂ × F$_3$ II 2 & 4 ♀.								
1	Coloured.	......	Rose.	Black.	Normal.	Slight.	......	Died first week.
2	Coloured.	......	Rose.	Black.	Normal.	Slight.	......	Died first week.
3 ♂.	Coloured.	Normal.	Rose, trifid.	Black.	Normal.	Complete.	Crest slight.	Very richly coloured.
4 ♂.	Coloured.	Normal.	Rose, trifid.	Black.	Normal.	Slight.	Crest very slight.	
5 ♂.	Buff chick. White.	Normal.	Rose, trifid.	Black.	Normal.	None.	Crest full.	Considerable brown on throat, most of three.
6 ♀.	Buff chick. White.	Normal.	Rose, trifid.	Black.	Normal.	Complete.	Crest full.	Slight brown on throat.
7 ♀.	Buff chick. White.	Normal.	Rose, trifid.	Unpigmented.	Normal.	Complete.	Crest not full.	Slight brown on throat.

1913. F_4. Brood III. Hatched 1913. Same parentage as Brood II.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1 ♀.	White.	Normal.	Rose.	Black.	Normal.	Slight.	Very slight.	Pale buff colour on throat.
F_4 IV. Hatched June 4. F_3 IV 1 ♀ × F_3 I 2 ♂.								
1 ♀.	White.	Silky.	Rose.	Black.	Normal.	Very slight.	None.	Deep buff on breast and throat.
2 ♀.	White.	Normal.	Rose.	Unpigmented; pig. on abd.	Normal.	Slight.	None.	Little buff on throat.
3 ♀.	Coloured.	Normal.	Rose.	Unpigmented; pig. on abd.	Normal.	Complete.	None.	Head light coloured.
4 ♀.	Coloured.	Normal.	Rose, trifid.	Black.	Normal.	Clean legs.	Slight.	Head black.
F_4 V. F_3 I 1 ♂ coloured × F_3 III 9 ♀ white.								
1 ♀.	White.	Normal.	Rose, trifid.	Unpigmented.	*Double hallux* on both feet.	None.	Present.	Deep brown on throat in July.
2 ♀.	Coloured.	Silky.	Rose, trifid.	Pigmented.	Slightly double on right; normal on left.	None.	Slight.	Killed April 8, 1914.
3 ♀.	Coloured.	Silky.	Rose.	Pigmented.	Nearly double on left; normal on right.	None.	None.	
F_4 VI. F_3 I 1 ♂ coloured × F_3 III 10 ♀ white.								
1 ♂.	Coloured.	Normal.	Rose, trifid.	Pigmented.	Normal.	Complete.	Present.	
F_4 VII. Same pen as Brood II.								
1 ♀.	White.	Normal.	Rose.	Recessive; pig. on abd.	Normal.	Complete.	None.	Little buff on breast.

1913. F_4 VIII. Parents F_3 I 2 ♂ × F_3 IV 1 ♀.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1 ♂.	White.	Silky.	Rose.	Recessive; much pig. on abd.	Normal.	Complete.	?	Little brown on breast.
2 ♂.	White.	Normal.	Rose.	Black.	Normal.	Complete.	None.	Sept. 6, much brown on breast Oct. 19.
3 ♀.	White.	Normal.	Rose, narrow, trifid.	Black.	Normal.	Complete.	Flat crest.	Pigment coming on back. Brown on breast.
4 ♀.	White.	Normal.	Rose, narrow, trifid.	Recessive; pig. on abd.	Normal.	None.	Flat crest.	Moderate brown on breast.
5 ♂.	White.	Normal.	Rose, trifid.	Black.	Normal.	None.	Present.	Very little brown on breast.
6 ♀.	Coloured.	Silky.	Rose, pointed.	Recessive; pig. on abd.	Normal.	None.	None.	Much blacker plumage than others; black head.
7 ♂.	Coloured.	Silky.	Rose, trifid.	Recessive; pig. on abd.	Normal.	Complete.	Crest.	Sexed, Sept. 27.
8 ♂.	Coloured.	Normal.	Rose, pointed.	Recessive; pig. on abd.	Normal.	Complete.	None.	
9 ♂.	Coloured.	Normal.	Rose, trifid.	Recessive; pig. on abd.	Normal.	Complete.	Moderate.	
10 ♂.	Coloured.	Normal.	Rose.	Black.	Normal.	Complete.	Crest.	
11 ♀.	Coloured.	Normal.	Rose.	Black.	Normal.	None.	?	
12 ♀.	Coloured.	Normal.	Rose.	Black.	Normal.	None.	?	

1913. F_4 IX. Parents F_3 I 1 ♂ coloured × F_3 III 10 ♀ white.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Leg.*	*Crest.*	
1 ♂.	White.	Normal.	Rose, pointed.	Recessive; black on abd.	Normal.	Complete.	None.	Little brown on breast.
2 ♂.	Coloured.	Normal.	Rose.	Recessive; black abd.	Normal.	Complete.	?	Light head; killed by rats Jan. 2, 1914.
3 ♂.	Coloured.	Normal.	Rose, pointed.	Recessive; black abd.	Normal.	Complete.	None.	Light head; killed by rats Jan. 1914.
4 ♀.	Coloured.	Normal.	Rose, pointed.	Recessive; black abd.	Normal.	Complete.	None.	Light head; killed by rats Jan. 1914.
5 ♂.	Coloured.	Normal.	Rose, trifid.	Black.	Normal.	Complete.	Present.	Light head.
6 ♀.	Coloured.	Normal.	Rose, pointed.	Black.	Double hallux on both feet.	Complete.	Present.	Slight crest; point of comb blunt and bent up. Light head.

1914. F$_5$ I. Parents F$_4$ V 1♀, F$_4$ VIII 4♀ × F$_4$ II 3♂ coloured.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1	Buff.	......	......	......	......	......	......	Died in down.
2	Coloured.	......	......	......	......	......	......	Died in down.
3	Coloured.	......	......	......	......	......	......	Died in down.
4 ♂.	Coloured.	Normal.	Rose, trifid.	Black.	Double hallux on both feet.	Moderate.	Present.	Killed Nov. 14, 1914.

F$_5$ II. Parents F$_4$ V 2♀ silky, F$_4$ V 3♀ silky × F$_4$ VIII 2♂ pile.

1	Buff.	......	......	......	......	......	......	Died first day.
2	Coloured.	......	......	......	......	......	......	Died first day.
3 ♀.	White.	Normal.	Rose, pointed.	Black.	Double hallux on both feet.	Moderate.	None.	Much brown on breast.
4	Coloured.	......	......	......	......	......	......	Died before being fledged.
5	Coloured.	......	......	......	......	......	......	
6	Coloured.	......	......	Black.	Normal on left: extra hallux not completely separate on right.	......	......	

Hatched May 7. F_2 III. Parents F_1 VIII 6 ♀ × F_1 VIII 7 ♂, both dark silky.

	Colour in Chick.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1 ♀.	Coloured dark.	Silky.	Rose.	Recessive; pig. on abd.	Double hallux on left foot.	Slight.	Present.	Black crest, darker than parents.
2 ♀.	Coloured dark.	Silky.	Rose.	Recessive; pig. on abd.	Double hallux on left foot	Infinitesimal.	Present.	Black crest, darker than parents.
3 ♀.	Coloured light.	Silky.	Rose.	Recessive; pig. on abd.	Normal.	Slight.	Slight.	Intermediate in general colour.
4 ♀.	Coloured light.	Silky.	Rose.	Recessive; pig. on abd.	Normal.	None.	Slight.	Lighter, yellower head.
5 ♀.	Coloured light.	Silky.	Rose.	Recessive; pig. on abd.	Normal.	Slight.	None.	The lightest, quite light brown.
6 ♂.	Buff.	Silky.	Rose.	Recessive; pig. on abd.	Double hallux on both feet.	Moderate.	None.	Light brown on breast.
7 ♂.	Buff.	Silky.	Rose.	Recessive; pig. on abd.	Double hallux on both feet.	None.	Slight.	Brown on breast.
8	Buff.	......	......	......	......	......	...	Died first week.

Nov. 8, 1914. Nos. 3 & 4 in this brood have black heads, but they are lighter on the back than Nos. 1 & 2. No. 5 has light brown head.

F_5 IV. Parents F_4 VIII 4 ♀ pile × F_4 II 5 ♂ pile.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1 ♂.	White.	Normal.	Rose.	Black.	Normal.	Infinit.	Slight.	Brown on breast moderate.
2 ♂.	White.	Normal.	Rose.	Black.	Normal.	None.	Slight.	Little less brown on breast.
3 ♀.	White.	Normal.	Rose.	Black.	Normal.	None.	Full.	Brown on breast considerable.
4 ♀.	White.	Normal.	Rose.	Black.	Normal.	None.	Full.	Spots of brown on breast.
5 ♀.	White.	Normal.	Rose.	Black.	Normal.	None.	Full.	Spots.
6 ♀.	White.	Normal.	Rose.	Black.	Normal.	None.	Full.	Slight spots.
7 ♀.	White.	Normal.	Rose.	Black.	Normal.	None.	Full.	Very slight brown on breast.
8 ♀.	White.	Normal.	Rose.	Black.	Normal.	None.	Slight.	Very slight brown on breast.

Hatched May 17. F_5 V. Parents F_4 VIII 8 ♂ × F_4 IV 3 ♀, both light-coloured, normal.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1 ♂.	Coloured light.	Normal.	Rose, pointed.	Recessive: pig. on abd.	Normal.	Slight.	None.	
2 ♀.	Coloured light.	Normal.	Rose, pointed.	Recessive; pig. on abd.	Normal.	Moderate.	None.	
3 ♂.	Coloured light.	Normal.	Rose, pointed.	Recessive; pig. on abd.	Normal.	None.	None.	
4 ♀.	Coloured light.	Normal.	Rose.	Recessive; pig. on abd.	Normal.	Slight.	None.	
5 ♂.	Coloured light.	Normal.	Rose, pointed.	Recessive; pig. on abd.	Normal.	Complete.	None.	
6 ♀.	Coloured light.	Silky.	Rose.	Recessive; pig. on abd.	Normal.	Slight.	None.	
7 ♂.	White.	Normal.	Rose.	Recessive; pig. on abd.	Normal.	Complete.	Slight.	Brown on breast moderate.

1914. F$_5$ VI. Parents F$_4$ V 1 ♀ pile × F$_4$ VIII 7 ♂, dark silky.
Hatched June 3. Characters noted Oct. 24.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1 ♂.	Coloured.	Normal.	Rose, trifid.	Recessive; pig. on abd. slight.	Double hallux on left.	None.	Very slight.	One toe of double hallux very long.
2 ♀.	Coloured.	Normal.	Rose, truncate, several papillæ.	Recessive; pig. on abd.	Double hallux on both feet.	None.	Full.	Black head, dark type.
3 ♀.	Coloured.	Normal.	Rose, trifid.	Recessive; pig. on abd.	Double hallux on both feet.	None.	Rather full.	Light head, light type.
4 ♀.	Coloured.	......	......	......	......	......	......	Killed while I was in Australia.
5 ♀.	Coloured.	......	......	......	......	......	......	
6 ♂.	White.	Normal.	Rose, pointed.	Recessive; pig. on abd.	Double hallux on both feet.	None.	None.	Brown slight on throat but very slight on loins; one black feather on back.
7 ♂.	White.	Normal.	Rose, trifid.	Recessive; pig. on abd.	Double hallux on both feet.	Slight.	Moderate.	Little brown on throat.
8 ♂.	White.	Normal.	Rose, trifid.	Recessive; pig. on abd.	Double hallux on both feet.	None.	None.	Brown on breast and abdomen, but not very intense.
9 ♀.	White.	Normal.	Rose, trifid.	Recessive; pig. on abd.	Double hallux on both feet, but each only slightly cleft.	Moderate.	None.	Brown on breast and abdomen, but pale.

1914. F$_5$ VII. Parents F$_4$ VIII 3 ♀ pile × F$_4$ II 3 ♂, a very richly coloured cock.
Hatched July. Characters noted Oct. 24, 1914.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1 ♂.	Coloured.	Normal.	Rose, trifid.	Black.	Normal.	Moderate.	Slight.	Crest and end of comb intermediate; middle projection larger than lateral.
2 ♀.	Coloured.	Normal.	Rose, pointed.	Black.	Normal.	Moderate, rather slight.	None.	
3 ♀.	White.	Silky.	Rose, trifid.	Black.	Normal.	Moderate.	Large.	Brown on breast distinct but moderate.
4 ♂.	White.	Silky.	Rose, trifid.	Black.	Normal.	Moderate.	Rather large.	Brown on breast slight, but as this is male may be disappearing.
5 ♂.	White.	Silky.	Rose, pointed.	Black.	Normal.	Rather slight.	None.	Brown on breast, distinct but rather slight also on brows.
6 ♀.	White.	Normal.	Rose, trifid.	Black.	Normal.	Moderate.	Large.	Brown on breast considerable.
7 ♀.	White.	Normal.	Rose not clearly trifid, turned up at end.	Black.	Normal.	Moderate.	Moderate.	Much brown on breast, but not more than other years.

1915. F_6 I. Parents F_5 III 1 or 2 ♀ coloured, dark × F_5 VI 1 ♂ coloured, dark.
Hatched April 20.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1 ♀.	Coloured.	Normal.	Rose, pointed.	Recessive; pig. on abd.	Double hallux on left.	None.	None.	Dark type.
2 ♀.	Coloured.	Silky.	Single.	Recessive; pig. on abd.	Normal.	None.	Full.	Dark type, a little lighter.
F_6 II. Parents F_5 III 1 or 2 ♀ × F_5 VI 1 ♂. Hatched May 3.								
1 ♀.	Coloured.	Normal.	Rose.	Recessive; pig. on abd.	Double hallux on both feet.	None.	Full.	Dark type.
2 ♂.	White.	Normal.	Rose, trifid.	Recessive; pig. on abd.	Normal.	None.	None.	On June 27 slight pig. on throat, not only brown but also dark.
F_6 III. Parents F_5 V 2 or 4 ♀ × F_5 V 7 ♂, pale.								
1 ♀.	Coloured.	Normal.	Rose, trifid.	Recessive; pig. on abd.	Normal.	None.	None.	All these quite light in tone.
2 ♀.	Coloured.	Normal.	Rose, trifid.	Recessive; pig. on abd.	Normal.	None.	Slight.	
3 ♀.	Coloured.	Silky.	Rose.	Recessive; pig. on abd.	Normal.	None.	Very slight.	
4.	Buff. Killed as chick.							

1915. F_6 IV. Parents F_5 II 3 ♀ pile × F_5 V 5 ♂ coloured, light.
Hatched May 16.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1 ♀.	Coloured.	Normal.	Single.	Recessive; pig. on abd.	Normal.	Moderate.	None.	Light coloured type.
2 to 5.	Coloured chicks died in down							
6 ♂.	White.	Silky.	Rose, pointed.	Black.	Normal.	Moderate	None.	Brown on breast Aug. 7, but coming on back.
F_6 V. Parents F_5 IV 3 ♀ pile × F_5 VII 1 ♂. Hatched May 24.								
1 ♂.	White.	Normal.	Rose, trifid.	Full black.	Normal.	Moderate.	Slight.	
2 ♀.	White.	Normal.	Rose.	Black.	Normal.	Slight.	Slight.	Brown on breast.
3.	Coloured.	Chick died.						
F_6 VI. Hatched June 6, one coloured chick, killed accidentally. F_6 VII. Parents F_5 V 6 ♀ × F_5 V 7 ♂ pile.								
1 ♂.	Coloured.	Normal.	Rose, pointed.	Recessive; pig. on abd.	Normal.	Moderate.	None.	Light type.
2 ♂.	Coloured.	Normal.	Killed by rats.					Light type.
3 ♂.	Coloured.	Silky.	Rose, rather trifid.	Recessive; pig. on abd.	Normal.	Moderate.	None.	Light type.

F_6 VIII. Parents F III$_5$ 1 or 2 ♀ coloured, dark silky × F_5 VI 1 ♂ coloured, dark.
Hatched June 26.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1.	Coloured.	Normal.	Rose.	Recessive; pig. on abd.	Double hallux on right.	Very slight.	None.	Died July 17 before sexing.
2 ♂.	Coloured.	Normal.	Rose, trifid.	Recessive; pig. on abd.	Double hallux on both feet.	Slight, silky.	Very slight.	Very dark.
3 ♂.	White.	Normal.	Rose, pointed.	Recessive; pig. on abd.	Double hallux on left.	None.	None.	Moderate brown and black on breast, Sept. 11.
4 ♀.	White.	Silky.	Rose, trifid.	Recessive; pig. on abd.	Normal.	None.	Moderate.	Moderate brown on throat.

Hatched July 19. F_6 X. Parents F_5 II 3 ♀ pile × F_5 V 5 ♂ coloured, light.

1 ♂.	Coloured.	Normal.	Single.	Recessive; black on abd.	Normal.	Slight.	?	Killed Sept. 1.
2 ♀.	Coloured.	Silky.	Rose.	Black.	Normal.	Moderate.	None.	Light type.
3 ♂.	Coloured.	Normal.	Single.	Pigmented.	Normal.	Moderate.	None.	Light type.
4 ♂.	Coloured.	Normal.	Single.	Recessive; pig. on abd.	Double hallux on left.	Moderate.	None.	Light type.
5 ♂.	Coloured.	Normal.	Rose, pointed.	Pigmented.	Normal.	Rather full.	None.	Light type.
7 ♀.	White.	Normal.	Rose, pointed.	Recessive; pig. on abd.	Normal, ? lobe on outer edge.	Rather full.	None.	Brown on breast moderate.

F_6 XI. Parents F_5 IV 3 ♀ pile × F_5 VIII 1 ♂ coloured.
Hatched July 26.

	Colour of Plumage.	*Structure of Plumage.*	*Comb.*	*Pigmentation of Skin.*	*Toes.*	*Feathering of Legs.*	*Crest.*	
1.	Coloured.	......	......	......	......	......	......	Lost.
2 ♂.	Coloured.	Normal.	Rose, trifid.	Black.	Normal.	None.	Slight.	Light type, brown head.
3 ♂.	Coloured.	Normal.	Rose, trifid.	Black.	Normal.	Moderate.	Slight.	Light type, brown head.
4 ♂.	Coloured.	Normal.	Rose, blunt behind, with many papillæ.	Black.	Normal.	None.	Rather full.	Light type, brown head.
5 ♀.	Coloured.	Normal.	Rose, ditto.	Black.	Normal.	None.	Slight.	Light type, but with some black feathers on head and crest.
6 ♀.	Coloured.	Normal.	Rose, ditto.	Recessive; pig. on abd.	Normal.	None.	Slight.	Light type, but with some black feathers on head and crest.
7 ♂.	White.	Normal.	Rose, ditto.	Black.	Normal.	None.	Moderate.	Narrow tract of brown on breast, Oct. 10.
8 ♂.	White.	Normal.	Rose, ditto.	Black.	Normal.	Very slight.	Moderate.	Narrow tract of brown on breast, Oct. 10.
9 ♀.	White.	Normal.	Rose, ditto.	Black.	Normal.	Slight.	Full.	Narrow tract of brown on breast, Oct. 10.
10 ♀.	White.	Normal, but seemed to have a trace of silkiness.	Rose.	Black.	Normal.	Moderate.	Slight.	Narrow band of brown on throat and breast.

EXPLANATION OF PLATE I.

Fig. 1. Ventral surface of hen produced from cross between silky hen and black-red Bankiva cock, showing "pile" coloration. The dorsal surface is white without any of the reddish brown colour. The hen represented was F_5 *II 3 ♀ in the record of the pedigree, i.e., a hen of the second brood of* the 5th generation. It was killed Dec. 12, 1915, when 1 year and 8 months old.

Fig. 2. Dorsal surface of cock from the same cross, showing the "pile" coloration in the male. The colour is very slight compared with that of the female, and consists of a slight yellow tinge across the loins and on the upper wing-coverts. The rest of the body is pure white. The specimen was F_6 V 1 ♂ in the pedigree, *i.e.*, a cock of the fifth brood of the 6th generation. It was killed on Dec. 31, 1915, when 7 months old.

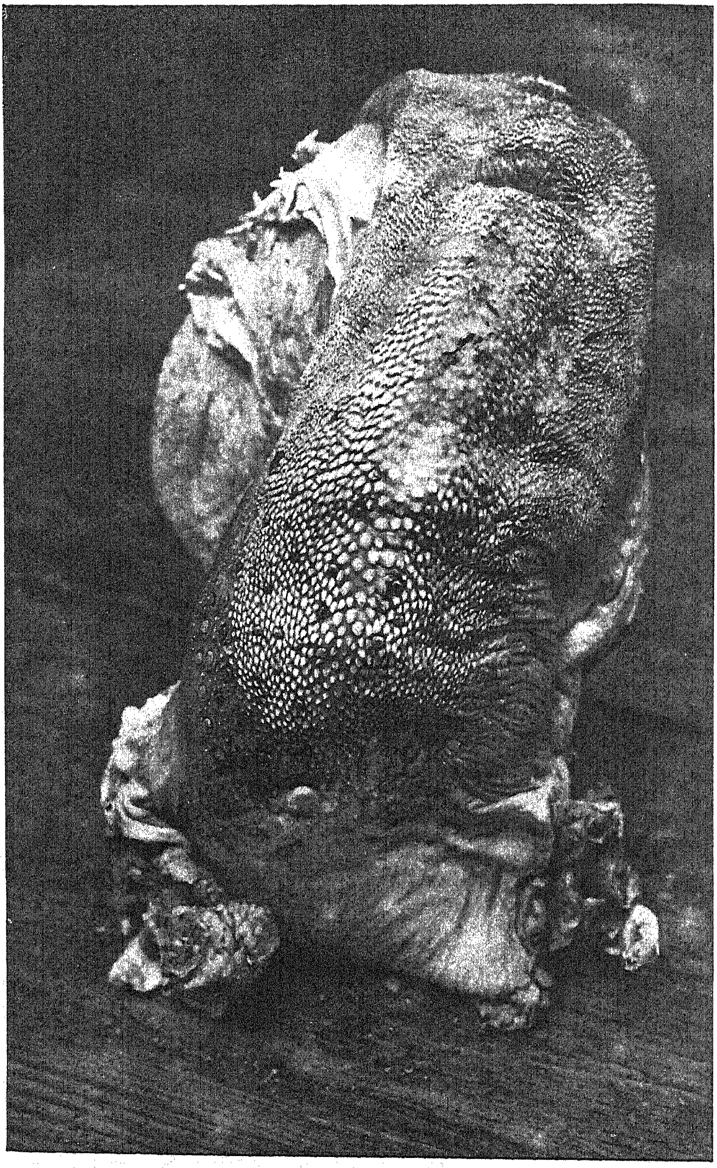

Photo. D. Seth-Smith, F.Z.S.

POSTERIOR PORTION OF TONGUE OF TAKIN (nat. size).

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13. Some Points in the Anatomy of the Takin (*Budorcas taxicolor whitei*). Based on the examination of a specimen in the Gardens of the Zoological Society of London. By Miss KATHLEEN F. LANDER, M.Sc., F.Z.S. (Hon. Acting Prosector to the Society).

[Received May 13, 1919: Read May 27, 1919.]

(Plate I.* and Text-figures 1–7.)

The animal in question was a male from North-west Bhutan, which was presented to the Zoological Society of London on June 22nd, 1909, and died in the Gardens on May 7th, 1918.

Unfortunately at that time it was impossible for any full examination of the anatomy to be made; a few notes were taken of the parts too large for preservation and some of the smaller organs were preserved in formalin. The account here given is, therefore, very incomplete, but may serve for comparison when next a Takin is available for examination.

Hodgson, when giving the first description of this animal, considered that its nearest affinity was with the Gnus, but that it would probably be placed between the Gnus and Musk Oxen in a classificatory scheme. Matschie created the group *Ovibovinæ* for *Budorcas* and *Ovibos* as a result of examination of the external characters, skull and metacarpus, and these two animals have usually been regarded as closely allied. Dr. Chalmers Mitchell has pointed out that they have in common the curious formation of the naso-frontal suture. In them a triangular process of the frontal fits deeply between the triangular proximal ends of the nasal bones, whereas in the majority of Ruminants the nasal bones project into the frontal area without divarication.

The Goral and Serow (*Nemorhædus goral* and *Capricornis bubalinus*) have also been grouped with the Chamois (*Rupricapra tragus*) and Rocky-Mountain Goat (*Haploceros montanus*) to form the Rupricaprine Section of the Bovidæ, and in some of the skull characters the Goral approaches the Takin as much as anything.

So far as I am aware no account has yet been given of the anatomy of the soft parts of the Rupricaprine section. Various anatomists have published accounts of the anatomy of the other Ungulata with which *Budorcas* has at one time or another been compared. In particular, the papers by Lönnberg on *Ovibos* and *Connochætes* have been consulted for comparative purposes.

Mr. R. I. Pocock recorded the external characters of the Takin described in this paper, both before and after death. In order to render this account as complete as possible I quote verbatim his observations published in the 'Annals and Magazine of Natural History' (6):—

"The rhinarium is continued inferiorly to the edge of the upper lip as a narrow mesially grooved strip, which is longer than in *Nœmorhedus* owing to the greater depth of the upper lip. Laterally an area of naked skin, narrower than in *Nœmorhedus*, is continued with a bold curve beneath the widely expanded nostrils, and curving round their posterior extremities passes into the dorsal portion of the rhinarium, which is much shorter from before backwards than in *Nœmorhedus*, being considerably more overgrown with hair.

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* For explanation of the Plate see pp. 204–6.

"The *feet* resemble in essential particulars those of the dried example figured and described in 1910, except that on the fore foot there is no trace of the transverse ridge of integument just where the hair of the pastern ceases in the interungual space. There is no trace of definite pedal gland, although the hair at the bottom of the interdigital depression in front is stuck together with secretion indicating activity of the skin at that spot. The hind foot is like the fore foot.

"There is no trace of *preorbital gland* or of *inguinal glands* in the ordinary sense of that term; but the two mammæ on each side, set as far out from the middle line as the outer edge of the scrotum, are close together, one in front of the other, in the centre of a distinct swelling like a small udder. When the skin is cut away, this swelling is seen to be caused by a blackish glandular mass like a small bunch of grapes, and blackish secretion could be squeezed through a single pore on the posterior teat with the use of considerable pressure. This unusual condition of the mammary gland in the male is worth putting on record, although, pending the examination of other specimens of *Budorcas*, it must be regarded, I think, as pathological in one individual.

"The *penis* is provided with a pendulous prepuce, three inches long, rising from the abdomen six inches in front of the scrotum. Just within the orifice of the prepuce the skin is highly glandular and overgrown with long hairs, which protrude from the aperture to form a tuft three or four inches long. The *glans penis* is apically attenuated and provided with a straight, moderately stout, urethral prolongation projecting some little way beyond the tip of the glans. Except for the greater elongation of the free portion of the urethral canal, the glans penis is very like that of *Nœmorhedus*."

Mr. Pocock points out that some marked differences may be found in these respects between *Budorcas* and *Ovibos*, particularly in the strong development of the rhinarium in the former and its great reduction in the latter, and in the prolongation of the urethral canal beyond an attenuated glans in the penis of the Takin, while in the Musk-ox the canal is not produced beyond the glans, which is blunt at its end.

In the presence of a preorbital gland and hairs between the hoofs *Ovibos* differs from *Budorcas*, as also in the arrangement of the four mammæ, the absence of a protruding tuft of hairs from the prepuce, and the presence of longitudinal ridges in its cavity.

The *tongue* of this Takin measures 270 mm. in length, and in front, where it is broadly rounded, 60 mm. in breadth, narrowing to 50 mm. in the middle and expanding again posteriorly to a width of 65 mm. Its dimensions thus correspond almost exactly with those of the adult male Musk-ox described by Lönnberg. 160 mm. from the anterior border is a transverse depression, slightly convex anteriorly, behind which the tongue shows the usual convexity of the posterior part of this organ. The position of the transverse groove, more than half way back on the tongue surface, is a point in which the Takin differs from the Musk-ox, agreeing with the Gnu.

On the anterior flat portion filiform and fungiform papillæ are found. These extend on to the under surface for a distance of 5 mm. back from the tip, but over the lateral border, 40 mm. back, they cover 15 mm. of the lower aspect. In this respect *Budorcas* resembles the Musk-ox, Gnu, Reindeer, Sheep, and Goat, but differs from *Bos*. As in *Ovibos* and *Connochætes*, the fungiform papillæ are very numerous on the under surface.

The filiform papillæ are small and flat in the centre, only just distinguishable to the naked eye and very closely set. Towards the sides they become more filiform and rather less flattened, and the same process of alteration in form takes place from before backwards, those at the sides being always more filiform than the central ones at the same transverse level.

80 mm. from the tip the lateral papillæ are distinctly elongated, tapering and recurved, a similar elongation of the central ones being found 40 mm. further back. In the transverse groove the papillæ are 2 mm. in length, and 1 mm. broad at the base, tapering to a fine point. In the greater narrowness and pointedness of the filiform papillæ the Takin is more like *Bos* than *Ovis*, *Ovibos*, or *Antilope cervicapra*.

The fungiform papillæ are small and scattered in the anterior central region; they have to be looked for here, while on the sides and at the tip they are the most noticeable structures on the tongue surface and are set about 3 mm. apart. In the middle of the tongue they become more prominent, but there are not many in the region lying between the groove and a line 7 mm. from the anterior border. At the sides and back of the central region these papillæ are about ½ a millimetre in diameter. Around the groove they are more numerous and measure 1 mm. across. In *Bos*, *Ovis*, *Capra*, and *Capreolus* fungiform papillæ are entirely absent on the central part of the anterior half of the tongue. The presence of small scattered fungiform papillæ in this region is characteristic of *Ovibos*, *Connochætes*, and *Rangifer*.

In the posterior part of the tongue behind the sulcus the filiform papillæ are long and recurved in the central region, becoming gradually shorter, thinner, and more hairlike laterally until on the lateral margin they are merely raised dots. Proceeding backwards the same transition takes place, but rather more rapidly. The fungiform papillæ increase in size as they pass backwards, becoming 2 mm. in diameter at the back.

A central strip, 10 mm. in breadth, is sharply differentiated from the rest of this part by being entirely devoid of fungiform papillæ, and by the character of the filiform papillæ. It gives the impression of being bordered by an irregular row of fungiforms. The filiform papillæ only maintain their long pointed character for a distance of about 20 mm. back from the transverse groove, becoming progressively smaller and more scale-like for a further 35 mm. back. Behind this point they again increase in size, but retain their scale-like form; some are as large as 3 mm. in diameter, and in form they are either circular or very slightly pointed; they are very hard and horny. At the lateral margins of the strip these pass rather abruptly into the long pointed form typical of the rest of the central region of the posterior half of the tongue. (*Cf.* Plate I.)

The well-defined central strip of *Budorcas* is not described for any other animal, but in *Rangifer* and *Capreolus* the centre of the back of the tongue is said to be destitute of fungiform papillæ. In *Ovibos* only the anterior one-third of this central region is devoid of fungiform papillæ. This part of the tongue seems to be more like that of *Bos* than is the tongue of the Musk ox.

Papillæ are present on the lateral aspect of the posterior part of the tongue in its anterior half, *i. e.*, as far back as the row of circumvallate papillæ. Papillæ are stated to be present on the lateral aspect of this part in the Musk-ox and some of the Cervidæ, but not in *Connochætes*, *Ovis*, or *Capra*.

It is in some cases very difficult to determine whether a given papilla on the back of the tongue is of the fungiform or of the circumvallate variety, as Lönnberg found in *Madoqua saltiana*. Counting the doubtful ones as circumvallate there are twenty-three of these on the left side and twenty on the right, arranged in four irregular rows. The fourth or outermost row appears only at the anterior end of the group. About fourteen of these are almost certainly circumvallate, and the number is thus comparable with that found in *Bos* (10–17) and *Ovibos* (12–15), but if the greater number be counted the Takin approaches the Sheep (18–24), *Capra* (16–17), or *Connochætes* (20) in this respect. The presence of four rows brings *Budorcas* into line with the Sheep; *Ovibos*, *Connochætes*, *Bos*, and *Rangifer* present only two rows. The grouping into rows is, however, very ill-defined in the Takin, and the papillæ are very variable in size. They form the usual V-shape, the arms of the V reaching forwards to a point about half-way back along the posterior portion of the tongue.

Along the side of the attached portion of the organ runs a low fold of mucous membrane extending forwards to a distance of 80 mm. from the tip. It bears several long pointed denticulations, which look upwards and backwards.

The *hyoid* bone is well-developed. The body is square, 30 mm. in size, bearing a small ridge on its anterior surface. The distance between the facets for the ceratohyals is 30 mm. The thyrohyal is 70 mm. in length and runs horizontally outwards* to meet the superior cornu of the thyroid cartilage. The ceratohyal is 40 mm. long, and runs forwards, outwards, and upwards to articulate with the epihyal, 25 mm. in length. This runs backwards, upwards, and outwards and bears the stylohyal, which passes backwards, outwards, and very slightly upwards for

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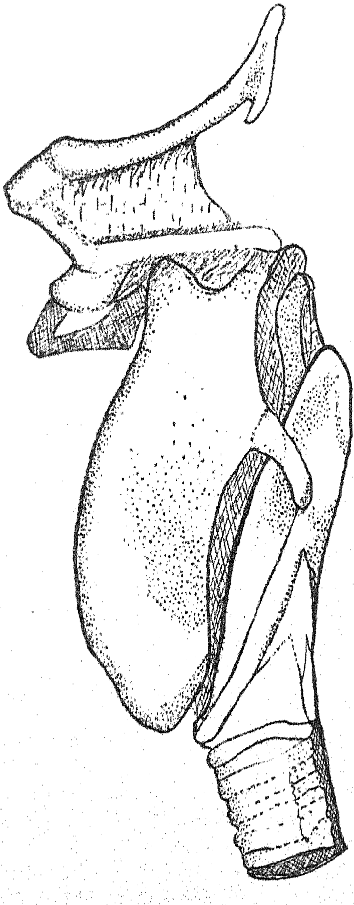
* *Note*: For the purposes of this description the larynx is regarded as being vertical in its long axis, as when the head of the animal is held high, and as figured.

Text-figure 1.



Lateral Aspect of Hyoid and Larynx of Takin.

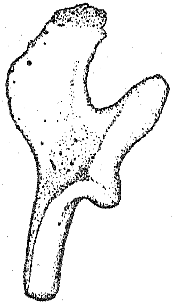
100 mm. before bifurcating widely into two terminal processes. The superior of these continues on the curve of the bone and ends bluntly truncated; the inferior is short and bluntly rounded and projects slightly forwards.

The bone is thus very like that of *Bos*, except for the preponderance of the ceratohyal over the epihyal in length. The hyoid of *Ovibos* is not described by Lönnberg.

The *larynx*, like that of the Musk-ox, is very elongated, owing to the expansion of the thyroid cartilage. Its maximum length is 200 mm. and its maximum transverse vertical diameter 105 mm. The expansion consists of a hollowing out and backward extension of the anterior part of the thyroid cartilage, which measures 180 mm. along its convexity, while the posterior border, from superior to inferior cornu, is only 60 mm. long. The amount of extension may be judged from the fact that the distance between the lowest (*i.e.*, most posterior) point of the thyroid to the insertion of the posterior cornu is 105 mm., while from the same point to the antero-inferior surface on a vertical plane is 70 mm.

The superior cornu is 25 mm. in length, and runs obliquely upwards and backwards, thus presenting an intermediate condition between the superior cornu of *Ovibos*, which passes nearly vertically upwards at right angles to the long axis of the larynx, and that of *Bos* or *Capra*, which runs parallel with that axis. (Text-fig. 1.)

Text-figure 2.



Arytenoid Cartilage of Takin.

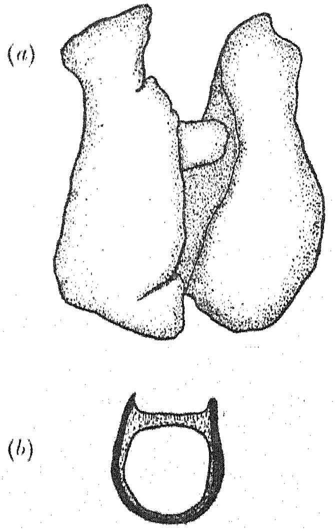
It is thus clear that the expansion of the thyroid cartilage met with in the Musk-ox, and approached in the larynx of the Blackbuck and Saiga, is carried very much further in the Takin. In the latter the bulbous extremity of the expansion is carried back far beyond the tip of the posterior cornu. In *Ovibos* the extremity is on a level with the tip of the cornu and the cartilage on the whole has a squarish appearance; in *Budorcas* it is about three times as long as broad. In *Capra*, *Cervus*, and *Capreolus* the length of the dorsal part of the cricoid is greater than the length of the thyroid; in *Ovibos* the cricoid length is 72 per cent. of the thyroid length; in *Connochætes* 80 per cent.; in *Bos* they are about equal, but in the Takin the percentage is only 33.

The inferior cornu of the thyroid in *Budorcas* is very much shorter and less curved than in *Ovibos*; it measures 50 mm. and is only slightly arched.

The cricoid is of the usual form; the expanded posterior plate is 60 mm. in depth and 55 mm. across. It presents a median posterior keel nearly 10 mm. in height. Owing to the extension of the anterior part of the thyroid the ring is very obliquely sloped, the anterior part lying at a lower level than the lowest part of the posterior part. (Text-fig. 1.)

The arytenoids are massive, 85 mm. in total length. The free apex is expanded into a thin, curved, and fenestrated plate. The vocal process is a rounded knob-like eminence. The muscular process is a long stout bar extending downwards and forwards for 40 mm. from the body. It is thus only 5 mm. shorter than the expanded free portion. (Text-fig. 2.)

Text-figure 3.



(*a*) Anterior Aspect of Lungs. (*b*) Transverse Section of Trachea.

The epiglottis is bluntly rounded at the apex, 50 × 35 mm. in size. Only about one-half of it is free. The surface is pitted. It is therefore similar to the epiglottis of the Gnu and Musk-ox.

The tracheal rings are irregularly imbricate. Their posterior ends are separated by a distance of 30 mm. and there is thus no posterior keel, in contrast to the trachea of *Bos* and *Connochætes*. There are 15 rings above the eparterial bronchus and then 4 succeeding ones before the bifurcation. The absence of keel gives the trachea of *Budorcas* a resemblance to that of *Ovibos*, but there is no dorso-ventral flattening. The ends of the rings in *Budorcas* project dorsally, whereas those of *Ovibos* appear to bend over, the terminations facing each other. The shape of the cavity is practically circular in the former animal and oval or kidney-shaped in the latter. (Text-fig. 3 *b*.)

The *lungs* are pyramidal in shape. The left lung shows no fissures whatever; the right lung has a well-marked upper lobe, very much smaller than the lower, but the fissure marking this off is incomplete at the upper border. (Text-fig. 3 *a*.)

There is a well-developed azygos lobe, measuring 130 × 80 mm.

The left lung of *Ovibos* is described as remarkable among the Ruminants for its simplicity, the upper lobe sitting with a broad base on the lower; the left lung of *Budorcas* is still more strikingly simple. The right lung is also markedly more simple than in other Ruminants.

ALIMENTARY SYSTEM.

The *paunch* consists of the usual two unequal sacs, lined by a mucous membrane presenting flattened, tongue-shaped papillæ, whose maximum length is 15 mm. and breadth 4 mm. These gradually become confluent, presenting a moss-like surface, and run into a reticulum, the cells of which measure about 20 mm. in diameter and are bounded by walls as high as 4 mm. or 5 mm. Secondary and tertiary ridges are also present.

The paunch is thus very like that of *Ovibos* and distinctly different from that of *Connochætes*, in which the papillæ are conical with blunt ends and there is a sharp dividing line between paunch and reticulum; the sacs of the paunch also are subequal in size in *Connochætes*.

Sixty-one folds may be counted in the psalterium; many of them are mere ridges; twenty-one of them form high folds. This is the same number as that named by Lönnberg for *Ovibos*.

In the abomasum seventeen folds were found, the animal thus agreeing roughly with *Bos* (14–16) and *Antilope cervicapra* (19), but having more folds than *Ovis* or *Capra* (13–16) or *Connochætes* (12–13), and fewer than *Ovibos*.

The small intestine measures 103 ft. in length, the large gut 38 ft., while the cæcum measures 2 ft. 3 ins. The colon is of a perfectly simple tubular type, with a uniform muscular coat, no sacculations and no appendices epiploices.

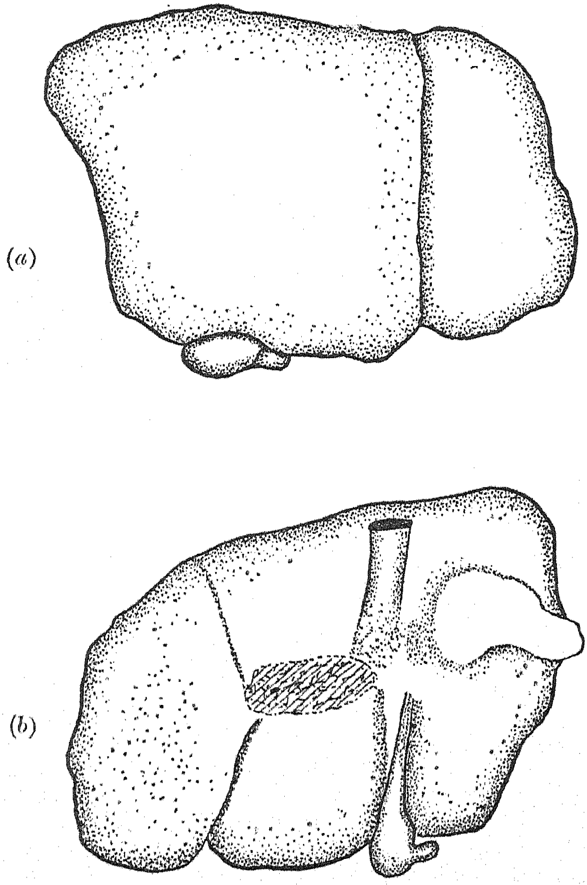
The small intestine is thus 2·7 times the large in length, a figure exactly corresponding to that given for the Blackbuck, and comparable with that of *Ovibos* (2·6) and various antelopes (2·3 to 2·7). In *Ovis* and *Capra* the small intestine is fully three times as long as the large, and in *Connochætes* the figure is nearer four, as it is in *Bos*.

Unfortunately no observations could be made on the grouping of the intestinal loops.

The *liver* is divided into right and left lobes, the former occupying three-fourths of the whole area of the anterior surface. This lobe is squarish in shape, with rounded corners, and is 13 inches in breadth, while the oval left lobe measures 3 inches.

These proportions present a marked contrast to those of *Ovibos*, in which the right and left lobes are almost equal in size. In *Bos* and *Ovis* the right lobe is somewhat larger than the left. (Text-fig. 4 *a*.)

Text-figure 4.



(*a*) Anterior, (*b*) Psterior Aspect of Liver.

The Spigelian lobe is practically undifferentiated, as in *Connochætes*; it can be distinguished in the livers of the other animals mentioned for comparison.

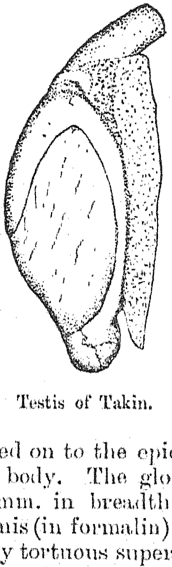
The lobus caudatus is club-shaped, with its narrow end reaching out to the right margin.

The quadrate lobe is square in shape, $4\frac{1}{2}$ inches in breadth (text-fig. 4 *b*).

The gall-bladder is definitely bilocular and lies in the fossa between the quadrate and right lateral lobes, extending for some distance below the inferior margin. The bile-duct is highly valved. The gall-bladder thus seems distinctly different in form from that of *Ovibos*; it is also situated rather nearer to the right margin than in the Musk-ox. On the whole it is more like that of *Bos* or *Connochætes*.

The *testis* is oval, or, with the epididymis, spindle-shaped. The total length of the testicle is 85 mm., of which 21 mm. represents globus minor and 8 mm. globus major. The width is 40 mm. and thickness 30 mm. The head of the epididymis enwraps the anterior free border of the gland for the upper half of its length. It is only connected with the tunica albuginea of the testis around its periphery; the rest of the expanded head can be separated from the testis by tearing the lax areolar tissue between them. The organ is enclosed in a thick tunica vaginalis of the usual type, reflected on to the epididymis along the whole length of its head and body. The globus minor forms a free bulbous projection, 20 mm. in breadth, 15 mm. in depth and thickness. The epididymis (in formalin) is salmon-pink in colour, marked by numerous very tortuous superficial veins. The tunica albuginea is bluish white; the gland shells out of this capsule with the greatest ease, being separated from it by a number of large tortuous veins which run mainly in a longitudinal direction and make marked grooves on the surface of the soft brown testis. The gland and capsule are only connected by a very small strand at the upper pole. (Text-fig. 5.)

Text-figure 5.



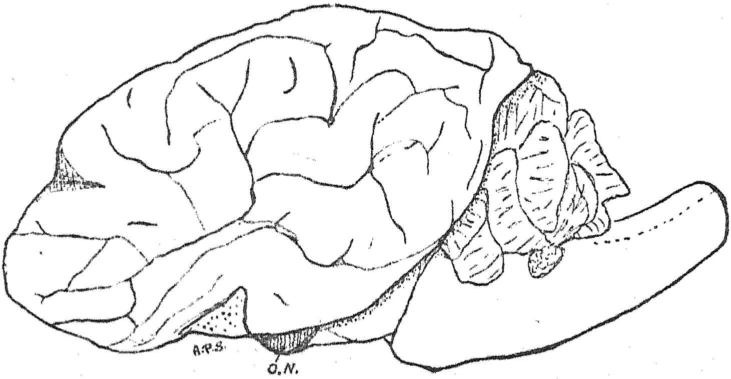
Testis of Takin.

The vas deferens ascends beside the body of the epididymis, accompanied by two large veins. Above the caput it is joined by a large pampiniform plexus, forming a spermatic cord 17 mm. in thickness.

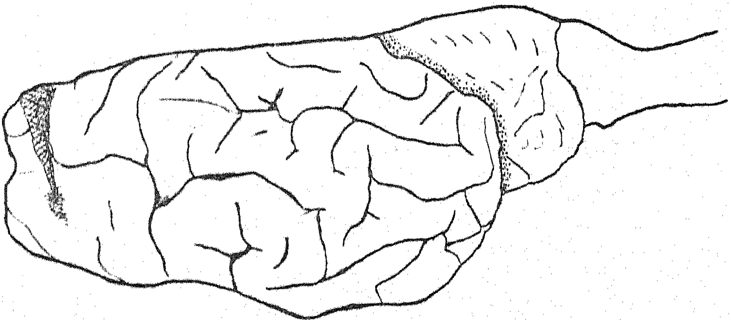
The *brain* is 119 mm. in total length, of which 104 mm. represent the length of the cerebral hemispheres. Its breadth is 91 mm., and height 58 mm. It is thus distinctly small when compared with the size of the animal.

The olfactory bulbs are not present, and there is a wide saw-cut across the frontal region; otherwise it is in excellent condition. It has been preserved in formalin for twelve months.

Text-figure 6.



A.P.S.=Anterior Perforated Spot. O.N.=Optic Nerve.



Dioptograph outlines of Lateral and Superior Aspects of Brain.

The optic lobes are completely concealed and the projecting occipital poles of the hemisphere rest on the anterior aspect of the cerebellum, which is sloped to receive them.

The hemispheres are well fissured, the sulci being deep and complicated and almost all of them having numerous hidden sulci on their walls which run from the surface perpendicularly inwards to the floor of the main fissure.

The "*pseudo-Sylvian*" fissure extends on the lateral aspect for a distance of 30 mm. It is 16 mm. deep on the infero-lateral margin and conceals a good deal of operculated cortex marked by hidden perpendicular sulci, converging towards a central point near the highest part of the fissure. 8 mm. and 15 mm. from its upper extremity the fissure gives off small branches which run backwards and forwards respectively.

The two *terminal* sulci are deep and well-marked. The anterior one commences on the inferior aspect of the frontal pole and runs downwards and backwards for 15 mm. and then turns backwards to pursue a course parallel with the rhinal fissure. It is 5 mm. deep. The posterior terminal sulcus is only 15 mm. long. Between these and the rhinal fissure is a gyrus of 5 mm. breadth.

The notch on the rhinal fissure, said to represent the feline "pseudo-Sylvian," lies 6 mm. behind the confluence of the anterior and posterior terminal sulci and is 10 mm. long.

There is a typical Ungulate *suprasylvian* arch, 16 mm. deep, with a horizontal ramus 30 mm. long and vertical rami 13 mm. in length. The gyrus surrounding the "Sylvian" fissure is in most places over 12 mm. in width, but the termination of the fissure reduces it to 5 mm.

The posterior branch runs back to the occipital pole. It is prolonged forwards beyond the posterior vertical limb of the suprasylvian, reaching to within 5 mm. of the "Sylvian" fissure. A shallow groove passes over the intervening gyrus, connecting the two sulci.

The *sulcus obliquus of Holl* is represented by a triradiate sulcus of which one branch runs forwards 15 mm. above the rhinal fissure to a distance of 7 mm. from the "Sylvian"; another upwards to 7 mm. from the posterior branch of the suprasylvian; while the third passes backwards and downwards to a point 5 mm. from the hind end of the rhinal on the inferior aspect. Also belonging to this complex is a small isolated sulcus, 7 mm. long, lying between the anterior ramus of the triradiate and the forward prolongation of the posterior branch of the suprasylvian.

A small curved *sulcus perpendicularis*, 8 mm. long, lies between the "Sylvian" and suprasylvian.

The *diagonal* sulcus is 22 mm. long and lies in the usual position round the end of the anterior vertical limb of the suprasylvian sulcus. Its extremities both curve upwards. A gyrus of 4 mm. width separates the two sulci. Its accessory sulcus appears to be absent.

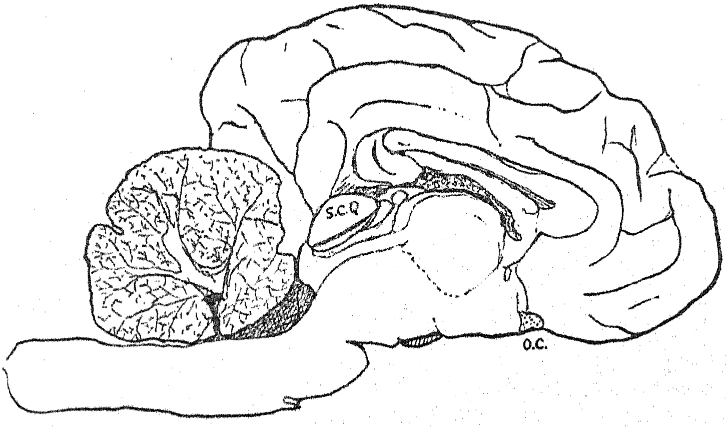
The *orbital* sulcus commences on the upper aspect of the frontal pole, 7 mm. from the supero-mesial margin. It first forms a curve, convex laterally, and then turns over the anterior margin and runs backwards to join the anterior terminal sulcus at its angle. The curved part is wide, but rather shallow, presenting a trench-like appearance; the hinder part is 10 mm. deep. A short cross-branch connects it with the front end of the rhinal.

From the junction of the anterior vertical and horizontal limbs of the suprasylvian a well-marked *transverse fissure* runs straight up to the supero-mesial margin. Into this, half way up, runs the *coronal*, which passes straight backwards from the tip of the frontal pole, a distance of 45 mm.

The *calcarine*, *intercalcary*, and *cruciate* sulci form one continuous furrow, cutting the supero-mesial margin 40 mm. behind the frontal pole and running downwards and forwards on the lateral aspect for 16 mm. Its end is separated from the coronal sulcus by a gyrus of 5 mm. breadth.

The *lateral* sulcus starts 5 mm. behind the transverse sulcus as a short straight sulcus, 15 mm. long. The hinder end of this is embraced by the widely bifurcated anterior end of another longitudinal sulcus which pursues an undulating course backwards for 40 mm., ending by bifurcating widely 9 mm. in front of the occipital pole. This gives off four short branches in its anterior half, two up and two down. The latter reach to within 5 mm. of the suprasylvian; elsewhere the gyrus separating the two sulci is 13 mm. broad. The lateral sulcus, as in most Ungulata, is obliquely placed, so that it approaches the mesial margin more nearly at its anterior end.

Text-figure 7.



Dioptograph outline of Mesial Aspect of Brain.

S.C.Q.=Superior Corpus Quadrigeminum. O.C.=Optic Chiasma.

The *ectolateral* sulcus lies between and parallel with the preceding and the posterior branch of the suprasylvian. It is 20 mm. long and its posterior bifurcation forms a vertical sulcus, 25 mm. in length, running parallel with the hind margin of the hemisphere. Across the anterior end of the ectolateral sulcus lies a vertical sulcus 20 mm. long separated from it by 3 mm.

A small curved *entolateral* sulcus, concave mesially, 15 mm. in length from tip to tip, lies between the lateral sulcus and the supero-mesial margin. In front of this, lying mainly on the mesial aspect, is an oblique straight sulcus, 25 mm. in length.

The *rostral* sulci are well marked; in front of the cruciate-like sulcus lies an H-shaped sulcus, and parallel with the anterior margin of the brain runs a curved sulcus 30 mm. long and 5 mm. deep.

Sulci subcinguli are represented by a longitudinal sulcus, broken in the middle, placed between the intercalary sulcus and the corpus callosum. The anterior part, 25 mm. long, curves over the genu and bifurcates widely, the lower limb continuing the curve, the upper running upwards between the two genual sulci. Behind the splenium lies a vertical sulcus which is a branch of the *calcarine*. This latter is 28 mm. long and 10 mm. deep. The intercalary is 15 mm. deep at its commencement; it arises from the calcarine about the mid-point of the latter.

The *rhinal fissure* is well marked posteriorly; in its depths is a good deal of buried cortex. It turns round the occipital pole and runs up nearly to the posterior end of the calcarine. The hippocampal convolution is 5 mm. broad anteriorly and below the "Sylvian" fissure expands into a broad triangular mass, 40 mm. along the base and 25 mm. from base to apex. Near its posterior angle this is marked by a horizontal sulcus 10 mm. long. The apex forms a well-marked "pseudo-temporal lobe," extending downwards and forwards over the crus cerebri and optic tract to the anterior perforated spot.

The *supra-callosal gyrus* is 8 mm. in breadth and subdivided by a well-marked small vertical sulcus into a larger outer mass, or gyrus of Andreas Retzius (hippocampus nudus), 5 mm. in breadth, and a smaller pyriform dentate fascia, the narrow end of which lying behind the splenium is 2 mm. wide, the broader end 5 mm. The sulcus limitans is also well marked.

The anterior corpus quadrigeminum measures 15 mm. in length by 12 mm. in breadth, while the posterior is 7 mm. in antero-posterior diameter and 9 mm. transversely.

So far as I am aware the brains of the Musk-ox and Gnu have not been described. For comparison, therefore, two brains from the Society's collection have been used, those of a Barbary sheep and an Anoa. The latter is characterised by Elliot Smith as the simplest and most generalised Ox-brain. The three brains are very nearly the same size and have been preserved in formalin for about the same time.

The brain of *Budorcas* appears much simpler than that of *Ovis*, owing chiefly to the absence of the numerous small isolated sulci or secondary branches of the main sulci which are found in the sheep. The cruciate upturning of the intercalary sulcus is rather less marked in *Ovis* and the transverse sulcus does not meet the suprasylvian. The arrangement of the orbital is rather different; this sulcus does not join the anterior terminal but the rhinal in *Ovis*. The Sylvian appears to rise from the rhinal and the diagonal is distinctly U-shaped, embracing the anterior vertical limb of the suprasylvian sulcus. These last two features are not constant in the ovine brain, however, and are not seen in the sheep brain figured in the Catalogue of the Museum of the Royal College of Surgeons.

Where the brain of the Takin differs from that of the sheep it agrees with the bovine type represented by the Anoa. The arrangement of orbital, anterior terminal and rhinal, and the relative positions of the transverse, coronal and suprasylvian sulci are almost identical in these two, but the cruciate sulcus is even less marked in the Anoa than in the sheep. The development of this sulcus seems to be partly associated with the position of the coronal sulcus with reference to the supero-mesial margin. In the Anoa the gyrus between them is less than 3 mm. in width, in the sheep 7 mm., but in the Takin 16 mm. There is thus room for a long "cruciate" sulcus on the lateral aspect in the Takin, for a very short one only in the sheep, and in the bovine brain the cruciate upturning is confined to the mesial aspect.

Budorcas differs markedly from the bovine type in the absence of any approach to the curious "double" form of Sylvian fissure found in the ox-like brain.

The anterior corpus quadrigeminum is as much larger in the Takin than in the sheep as it is larger in the sheep than in the Anoa, but the difference is slight and may be partly due to flattening consequent upon preservation. The body is distinctly triangular in outline in mesial section in the Takin, oval in the sheep, and more flattened still in the Anoa.

A similar progressive change is seen in the relative position of the supra-callosal gyrus and splenium. In the Anoa there is hardly any cortex directly behind the splenium; the whole mass lies underneath the corpus callosum; in *Ovis* the small pointed extremity of the hippocampus nudus lies in a line with the middle of the splenium; in *Budorcas*, as stated, the gyrus is 5 mm. broad horizontally behind the splenium.

The occipital pole is more pointed and projects rather further backwards over the cerebellum in the Takin and Anoa than in the sheep.

It seems hardly advisable to attempt to draw far-reaching conclusions of systematic importance from the scanty material at present available, more especially since there are no data on record of the anatomy of the other members of the Rupricaprine section.

Support is given to those who hold the affinity of *Budorcas* with *Ovibos* to be a close one; the two animals differ in but few points of their soft anatomy, and in many cases they share characters which differentiate them from other ruminant Artiodactyla.

The suggested relationship between *Connochætes* and *Budorcas* is not borne out; the resemblances between the two animals are few and far between and are mostly points of detail and minor importance.

Between *Bos* and *Ovis*, *Budorcas* seems to hold an intermediate position, agreeing now with one and now with the other, but a definite pronouncement as to the systematic position of the Takin among the Artiodactyla would be unjustifiable until many more observations on the anatomy both of *Budorcas* and of allied Ruminants have been placed on record.

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EXHIBITIONS AND NOTICES.

February 4th, 1919.

Dr. S. F. Harmer, F.R.S., Vice-President,
in the Chair.

The Secretary read the following reports on the Additions made to the Society's Menagerie during the months of November and December, 1918:—

November.

The registered additions to the Society's Menagerie during the month of November were 433 in number. Of these 3 were acquired by presentation, and 430 were deposited.

The following may be specially mentioned:—

1 Kea Parrot (*Nestor notabilis*), from New Zealand, presented by Lady Ian Hamilton, on November 27th.

December.

The registered additions to the Society's Menagerie during the month of December were 58 in number. Of these 45 were acquired by presentation, 12 were deposited, and 1 was received in exchange.

The following may be specially mentioned:—

1 Chimpanzee (*Anthropopithecus troglodytes*), from Sierra Leone, deposited on December 6th.

A collection of 32 lizards, including 8 Starred Lizards (*Agama stellio*), from Salonika, sent by Capt. W. D. Motton and G. H. Colt, F.R.C.S.

Mr. C. Davies Sherborn, F.Z.S., exhibited and made remarks on a letter written in 1693, by Malpighi to Dr. Mathew Faber.

Sir Douglas Mawson gave a lantern exhibition of Australasian Antarctic and Sub-Antarctic Life, and made the following remarks:—

The immense area of the Southern Seas supports abundant marine life which, if not utilized by man directly, is indirectly converted into useful products, such as Seals and Penguins. The tameness of these creatures makes them an easy prey to man, who finds therein remuneration from the marketing of blubber, oils, and skins. This traffic is on the increase, and it is quite certain therefore that unless the killing of these creatures is controlled, and regulations enforced for their proper protection, the species in many instances will rapidly become extinct—a fate that has already overtaken the valuable animals in many Sub-Antarctic lands.

Even Macquarie Island, a dependency of Tasmania, has been so worked by New Zealand sealers that it has also suffered. Nevertheless, it still abounds in most types of Sub-Antarctic life, and is the most ideal spot in those seas to be retained as a National Reserve for the protection and propagation of the various species of Penguins and Seals. This little island, which lies buried in mist and fog amidst the turmoil of the great rolling seas that sweep unchecked around the Globe in those latitudes, is one of the wonder spots of the world, for to this ocean sanctuary flock the seal and bird life of millions of square miles of the surrounding waters. It is the great focus of such life in the Autralasian Sub-Antarctic, and an indescribable attractive force impels the land-seeking life in those wide seas towards its shelter. The Penguins throng the beaches, and it is one of the few havens left to the great elephant-seals. Seal and bird life, with which the island still teems, has been greatly restricted as a result of the slaughter by the sealers. Within five years after the discovery of the island, the Fur-Seal was almost exterminated, and the species is now virtually extinct. A species of flightless Parrot is now non-existent, while the noble King Penguin has dwindled in numbers until it is now represented only by one small rookery at Lusitania Bay.

Turning to the Australasian Antarctic shore, the great abundance of seals, penguins, and whales will sooner or later attract exploiters, and it is well that the responsible Governments should legislate ahead in the interest of the continuance of the species.

February 18th, 1919.

A. Smith Woodward, Esq., LL.D., F.R.S., Vice-President, in the Chair.

The Secretary read the following Report on the Additions made to the Society's Menagerie during the month of January 1919:—

The registered additions to the Society's Menagerie during the month of January were 42 in number. Of these 21 were acquired by presentation, 9 were deposited, 10 were received in exchange, and 2 were purchased.

The following may be specially mentioned:—

2 Lion Marmosets (*Leontocebus rosalie*), from S.E. Brazil, presented by Sir George Noble, Bt., F.Z.S., on January 25th.

2 Bennett's Wallabies (*Macropus bennetti*), from Tasmania, purchased on January 25th.

2 Caspian Terrapins (*Clemmys caspica*), from Palestine, presented by Major E. E. Austen, D.S.O., F.Z.S., on January 15th.

March 18th, 1919.

Alfred Ezra, Esq., Vice-President
in the Chair.

The Secretary read the following Report on the Additions made to the Society's Menagerie during the month of February 1919:—

The registered additions to the Society's Menagerie during the month of February were 42 in number. Of these 12 were acquired by presentation, 18 were deposited, and 12 were purchased.

The following may be specially mentioned:—

1 Sallé's Amazon (*Chrysotis ventralis*), from St. Domingo, presented by Lady Edith Windham, on February 21st.

1 Starred Tortoise (*Testudo elegans*) and 1 Ceylonese Terrapin (*Nicoria trijuga*), from Trincomali, presented by Mr. Edward Canham, on February 14th.

Mr. F. Martin Duncan, F.R.M.S., exhibited a series of photographs and lantern-slides of Marine Zoology, and drew attention to the great economic importance of marine biological investigation to the successful continuance of our sea-fishing industries.

April 8th, 1919.

Dr. S. F. Harmer, F.R.S., Vice-President,
in the Chair.

Dr. F. E. Beddard, F.R.S., exhibited and made remarks on three fœtal Sperm-Whales, drawing attention to the smallest fœtus exhibited, which measured four and a half inches in length.

Mr. R. I. Pocock, F.R.S., Curator of Mammals, gave an exhibition, illustrated by lantern-slides, to show some of the structural characters by which the genera of the Felidæ may be distinguished from each other; special attention being drawn to the formation of the feet in the Cheetah (*Acinonyx*), to the modifications of the hyoidean apparatus in the Lions, Tigers, Leopards, and Jaguars (*Panthera*), and to the position of the partition in the auditory bulla in other genera.

April 29th, 1919.

Prof. ERNEST W. MACBRIDE, D.Sc., F.R.S., Vice-President, in the Chair.

The SECRETARY read the following Report on the Additions made to the Society's Menagerie during the month of March 1919:—

The registered additions to the Society' Menagerie during the month of March were 147 in number. Of these 120 were acquired by presentation, 8 were deposited, 5 were received in exchange, 10 were purchased, and 4 were bred in the Menagerie.

The following may be specially mentioned:—

2 Spotted Hyænas (*Hyæna crocuta*), from Africa, purchased on March 22nd.

1 Leopard Cat (*Felis bengalensis*), 2 Pandas (*Ælurus fulgens*), 2 Malabar Squirrels (*Ratufa maxima*), from India, purchased on March 27th.

1 Wild Boar (*Sus scrofa*), from Crécy, presented by Gen. Sir Henry Rawlinson, on March 12th.

An American Bison (*Bison americanus*), from North America, and one English Park Bull (*Bos taurus*), from Woburn, deposited on March 24th and March 26th.

2 Meyer's Parrots (*Pœocephalus meyeri*), from S.E. Africa, presented by the Marques of Tavistock.

1 Mikado Pheasant (*Calophasis mikado*), from Mt. Arizan, Formosa, received in exchange.

3 Himalayan Monauls (*Lophophorus impeyanus*), purchased.

Mr. T. GERRARD, F.Z.S., exhibited a series of heads of Waterbuck (*Kobus*), collected by Dr. Digby, and drew attention to points of interest relating to the variation in size and shape of the heads.

Dr. W. T. CALMAN, F.Z.S., exhibited and gave a detailed account of various Marine Boring Animals, including *Chelura*, *Pholas*, *Teredo*, etc., and drew attention to the economic importance of the scientific investigation of such Marine

Animals in relation to the serious damage caused by them to the timbers of wooden ships and to piers, and to the masonry of breakwaters and similar constructions.

In the absence of Mr. GEORGE JENNISON, the SECRETARY exhibited a series of lantern-slides of a Chimpanzee, the property of Dr. K. Butter, of Cannock, Staffordshire, which had been successfully kept alive in the open air in England for eight years. In a short note accompanying the slides Mr. Jennison gave the following particulars:—

"Members of the Society will be interested in the unique success of Dr. K. Butter at Cannock, Staffordshire, in keeping a Chimpanzee in the open air in England without artificial heat for eight years. The doctor, who is a keen naturalist and the possessor in normal times of a fine and varied collection of animals and birds, purchased Antony the chimpanzee in question (*Anthropopithecus troglodytes niger*) at Liverpool in 1910. He was told that the animal was from the Congo region and was three years old, but as it weighed only 14 lbs. it was probably younger. It weighed last summer 84 lbs. Antony was kept during the whole period in a brick building facing south-west, slept in straw and had no artificial heat, summer or winter; he made good use of the swings and perches in the exercise pen and took great interest in trying, not always unsuccessfully, to break them. He was very fond of Dr. Butter's dog and delighted to play with and pull it about, and he would also play for hours with the tame ocelots. Ladies and strange animals he disliked, but without showing any vindictive feeling towards them; injuries he resented and remembered.

As is the case with most chimpanzees he recognized few masters, only the doctor and the chauffeur could command his obedience; with them he could be trusted at liberty and naturally enjoyed much freedom. His dietary, in which there was no meat, consisted of milk, milk and bread, tea, coffee, cocoa which he liked very sweet, bread with jam or black treacle, nuts, locust beans of which he ate great quantities, all kinds of fruit, carrots, turnips, potatoes raw or boiled in their jackets, and water to drink. As a luxury he had grapes or raisins and sweets of all kinds, especially toffee and chocolates."

May 13th, 1919.

Prof. ERNEST W. MACBRIDE, D.Sc., F.R.S., Vice-President,
in the Chair.

The SECRETARY exhibited two photographs of a living Okapi, and stated that the animal had been in the possession of its present owners for a period of over three years. The photographs showed that it was a young animal, and that probably, as in the case of the Giraffe, the Okapi does not reach its adult stage until five or six years of age.

Mr. E. G. BOULENGER, F.Z.S., exhibited a series of living specimens of British Rats and their varieties, and stated that during the past four years there was evidence that the so-called Old English Black Rat had increased in numbers.

Lt-Col. S. MONCKTON COPEMAN, F.R.S., exhibited a series of lantern-slides made from carefully prepared charts to illustrate his "Experiments on Sex Determination."

May 27th, 1919.

A. SMITH WOODWARD, Esq., LL.D., F.R.S., Vice-President, in the Chair.

The SECRETARY read the following Report on the Additions made to the Society's Menagerie during the month of April 1919:—

The registered additions to the Society's Menagerie during the month of April were 148 in number. Of these 50 were acquired by presentation, 20 were deposited, 1 was received in exchange, and 77 were purchased.

The following may be specially mentioned:—

5 Californian Sea-Lions (*Otaria californiana*), from California, purchased on April 19th.

1 Brown Bear (*Ursus arctos*), from Murmansk, presented by the Captain and Officers of H.M.S. 'Ecellent' on April 30th.

1 Moufllon (*Ovis musimon*) (Sardinia); 6 Llamas (*Lama gluma*) (Peru), bred in Europe; 1 Hybrid Zebra and Donkey (*Equus grévyi* × *E. asinus*), bred in Europe, deposited by H.G. The Duke of Bedford, K.G.

2 Bennett's Wallabies (*Macropus bennetti*) (Tasmania), bred in Sussex, presented by Sir Edmund Loder, Bt., on April 16th.

1 Dusky Parrot (*Pionus fuscus*) (Guiana), received in exchange on April 1st.

5 Black-necked Swans (*Cygnus melanocoryphus*) (Southern South America), purchased on April 17th.

The SECRETARY exhibited, and made some additional remarks upon the photographs of the young living Okapi that were shown at the previous Scientific Meeting.

June 17th, 1919.

Prof. ERNEST W. MACBRIDE, D.Sc., F.R.S., Vice-President, in the Chair.

The SECRETARY read the following Report on the Additions made to the Society's Menagerie during the month of May 1919:—

The registered additions to the Society's Menagerie during the month of May were 169 in number. Of these 52 were acquired by presentation, 15 were deposited, 5 were received in exchange, 95 were purchased, and 2 were born in the Menagerie.

The following may be specially mentioned:—

1 African Hunting-Dog (*Lycaon capensis*), ♂ (S. Africa), purchased on May 7th.

1 Mikado Pheasant (*Calophasis mikado*), deposited by H.G. The Duke of Bedford, K.G., on May 14th.

1 Secretary-bird (*Serpentarius serpentarius*), from South Africa, purchased on May 7th.

1 South-African Amphisbæna (*Monopeltis capensis*), new to the Collection, from South Africa, deposited on May 28th.

Miss L. E. CHEESMAN, F.E.S., exhibited some living specimens of Light-giving Beetles from Cuba.

Mr. E. HERON-ALLEN, F.R.S., exhibited a series of lantern-slides demonstrating some of the results obtained in the experiments he had been carrying out in collaboration with Mr. ARTHUR EARLAND, F.R.M.S., on the cultivation of *Verneuilina polystropha* Reuss, in hypertonic sea-water and gem sand.

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PROCEEDINGS

OF THE

GENERAL MEETINGS FOR SCIENTIFIC BUSINESS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.

PAPERS.

14. Report on Methods of Rat Destruction. By E. G. BOULENGER, F.Z.S., Curator of Reptiles, Zoological Society of London. With an Introduction by P. CHALMERS MITCHELL, C.B.E., F.R.S., LL.D., D.Sc., Secretary to the Society.

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I. INTRODUCTION.

The destruction of Rats had a direct interest for the Zoological Society, as the abundant supply of food and shelter in the Zoological Gardens not only maintained a large indigenous population, but attracted rats from all the neighbourhood. In the beginning of 1919, the Council were of the opinion that it would be of interest to visitors, and of educational value, to arrange an Exhibition in the Gardens illustrating the natural history of Rats and Mice found in this country, the damage that they do to food, property and health, and the chief devices employed for their destruction. It was also decided to associate with the Exhibition an enquiry into the efficacy of these devices, with the object of recommending methods that were proved to be simple and practical. As the scheme appeared to be of public utility, it was agreed to seek advice and co-operation from the Board of Agriculture and Fisheries, and from the Local Government Board, as these Government Departments were known to be taking an active interest in what had become a national problem. The Board of Agriculture had already collected much information with a view to the introduction of legislation on the subject, and the Local Government Board had a large experience, especially on the relation of Rats to public health. Both Departments gave us immediate encouragement and assistance. Each made a grant of £100 towards the expenses of the investigation. They placed all the information in their possession at our disposal, gave us invaluable advice as to the method of arranging the exhibition and conducting the enquiry, and made our work easier and more productive. Throughout the progress of the enquiry, Mr. F. A. Fulford of the Board of Agriculture, and Mr. E. C. Read, the practical expert appointed to assist him, were in constant co-operation with us. The Council of the Zoological Society delegated Mr. E. G. Boulenger, Curator of Reptiles at the Gardens, to arrange the exhibition and conduct the research, with Mr. W. C. Harris as clerical and general assistant, and the necessary attendants. Various members of the Council with special scientific or practical knowledge, Mr. R. I. Pocock, F.R.S., and other members of the staff, and a number of private Fellows of the Society gave great assistance. Special thanks are due to Dr. C. J. Martin, F.R.S., and Mr. A. W. Bacot of the Lister Institute, to Dr. H. B. Newham of the London School of Tropical Medicine, Dr. W. J. Howarth, Medical Officer of Health for the City of London, Mr. W. Dalton, Mr. Max Baker, and Miss Frances Pitt for the loan of specimens, diagrams, etc. for the Exhibition; to a very large number of private persons and firms who lent apparatus, models, or samples of poisons, traps, etc.; to Dr. J. S. Warrack, Deputy Medical Officer of Health for the Port of London Sanitary Authority, for facilities to study the methods employed on ships: to Mr. J. Horne, Resident Manager of the Wood Lane Depot of the Royal Borough of Kensington, for facilities to carry out experiments at that depot; to Messrs. Lawson and Co. Ltd. of Bristol, Messrs. Boots Ltd., and the Proprietors of the Ratinol Company, for supplying large quantities of material for the experimental tests.

A separate file was kept for the records of each appliance, preparation, or method. The rats in the Gardens gave the opportunity for a large number of tests. Visits were made to shops, warehouses, farms, houses, rubbish-dumps, and so forth, so as to get information relating to different conditions. In Mr. Boulenger's Report, the practical conclusions arrived at are given first, and are followed by details regarding the methods found to be most successful, and those which yielded more uncertain or unsatisfactory results.

It is fortunate that the experiments point to the efficacy of means that are simple to use, not costly, nor, in the form recommended, dangerous to human beings or stock. The best bait is bread, the best gas is sulphur-dioxide, the best poison, Squills, and the best trap a device not dangerous to other animals. With regard to Squills, experimental research of a kind outside the scope of our enquiry is required. The substance is obtained from the common Mediterranean bulb, *Scilla maritima*, and is supplied by a few Firms in various forms, all of which are not efficacious. It is important that a chemical investigation should be made, to determine the active agent in the plant, and the best means of preparing and supplying it.

It is vital to the success of any attempt to reduce seriously the rat population of the country, that the work should be carried out simultaneously over large areas. Rats are migratory animals and will readily desert a locality which they find to be unwholesome, for an area in which measures are not being taken against them. They are also prolific, and will rapidly multiply beyond the capacity of areas in which they are undisturbed, and reinvade areas in which they had been reduced. These are matters for administrative action, and the provisions of the new Rat Destruction Bill, if carried out rigorously, should prove successful. It is also to be remembered that the winter season, now approaching, is the best time to make the attack. The numbers of rats are naturally at their lowest, and the scarcity of food in their outdoor haunts drives them to take baits more readily, and to approach traps less warily.

II. Report on Methods of Rat Destruction.

By E. G. Boulenger, F.Z.S., Curator of Reptiles, Zoological Society of London.

In connection with the Rat Exhibition held this summer in the Society's Gardens, investigations were actively pursued on various methods of rat destruction, and the following conclusions were arrived at:—

(1) That where the method necessitates baits being put down, the food offered should differ from that which forms the staple supply of the rats.

That dry bread is always accepted. That oatmeal, cheese, and tallow are also attractive baits, and that fish, lard and dripping, so frequently recommended, usually find favour only when no other food is available.

That faint traces of the oils of Rhodium and Aniseed, so commonly used to attract rats, instead of improving the bait have the contrary effect.

That the tastes of the Old English Black Rat (*Rattus rattus*) and the Common Brown Rat (*Rattus norvegicus*) are identical, at least in their surroundings in this country.

(2) That when rats are present in large numbers, and where it is not practicable to use gas, poisoning is the best and cheapest method to adopt for their destruction.

That of all the poisons we experimented with, Squill poison, the extract of the bulb of the Mediterranean plant *Scilla maritima*, which in the small quantities used in rat destruction is harmless to domestic animals, gave the most satisfactory results. That it may be used with greatest success in the liquid form, bread being soaked in a solution of the poison mixed with equal parts of milk.

That good results may also be obtained when Barium Carbonate is used in conjunction with Squill Since Barium Carbonate has a corrosive action on the mucous membrane of the stomach, compelling the rodents to leave their holes in search of water, the device of putting down bowls of liquid squill in the vicinity of the area treated should be resorted to in order that the rats may take more poison, thus ensuring their destruction.

(3) That the destructive power of virus is unreliable, and that better results are to be obtained by the use of Squill, Barium Carbonate, and other poisons.

(4) That trapping, provided the correct types of traps are employed, is to be recommended at all times of the year, and should be resorted to with special energy during the winter and in the periods between the poisoning campaigns, in order to destroy the surviving rats. That by persistent and skilful trapping the numbers of rats, even in badly infested localities, can be greatly reduced and kept under control.

That rats like passing through passages showing light at the far end, provided the middle of the passage is not dark. That of all the traps we tested, a wire tunnel-shaped cage trap, known to us as the Brailsford trap, and which embodied the above principles, gave the best results. In the type in question, which we regret is no longer being manufactured, the open doors at each end shut when the rat steps on a platform in the centre of the passage. With regard to this trap the results differed according to the height of the doors and passage, and that when these were eight inches high the largest percentage of captures was obtained. The width was found immaterial, provided of course it allowed for the free passage of the rat.

That the ordinary steel Gin trap and the "Nipper," a break-back trap with a moveable platform, were the only other traps to give very successful results, and with these the highest percentages of captures were obtained when they were covered with a wire tunnel of the Brailsford pattern, but without the doors, the traps being substituted for the platform.

That it is superfluous to avoid handling traps on the assumption, often entertained, that rats are detracted by the odour of man.

(5) That hunting with dogs and ferrets is a good method to adopt for the reduction of the rat population, 340 of the 1076 rats caught by us between the months of April and September being captured by the aid of ferrets and a single dog.

(6) That gassing, an expensive method, has a distinct advantage over all others in that it kills not only the adult and half-grown rats, but also the newly-born in their nests.

That Sulphur Dioxide is the best gas for use in rat destruction, and for killing rats on ships or in confined spaces it has no rival.

That it may also be used with some success in fumigating rat-holes in the open.

In connection with the above conclusions I have the following observations and recommendations to make:—

(*a*) Owing to rats when active measures are taken against them frequently migrating to neighbouring farms and estates, co-operation in their destruction is imperative, and the whole of a rat-infested area should be treated on the same day, and not in parts at different times as is at present generally done.

(*b*) A rick surrounded by 5½ feet high galvanized iron sheetings dug 2½ feet into the ground, is just as effectually protected, and at a much smaller cost, than when built on a massive non-portable staddle.

(*c*) At present the giving of rewards for rat-tails is indulged in by some and not by others. As those who do so cease when they discover they are called upon to pay for their neighbours' rats, the payment of such rewards should be made compulsory for all employers, at any rate during the winter months when scarcely any young are about, but when every adult at this time represents a potential increase in the numbers for the near future. This would go a long way towards keeping the vermin in check.

(*d*) In view of the recent undoubted increase in the numbers of not only the Common Brown Rat but also the Old English Black Rat, all ships should at regular intervals be subjected to treatment with Sulphur Dioxide gas by means of Sulphur Candles or a Clayton or some similar apparatus.

(*e*) The formation of a research school in the country, where further experiments on rat-destruction could be continued throughout the year, is desirable. That at this school the various poisons recommended should be made up and supplied direct to the rat-officers appointed by the County authorities; such officers being from time to time required to attend a course there, and be made acquainted with the latest developments.

It should be borne in mind that our investigations were conducted at a time of the year—May to September—when plenty of food is available for the rats, and that some of the methods which resulted in failures would possibly have succeeded if applied during the winter months.

The successes obtained deserve therefore, I think, special consideration.

We realized that the first step towards finding an effective method of rat-destruction, whether by means of poisons or traps, was to ascertain what baits the rodents found most attractive, as no device dependent on food being taken could, however ingenious, otherwise prove a success. The baits referred to in the table below were given to rats in captivity and in the wild state, and were nearly all put down together on over fifty different occasions. In the case of the rats kept in captivity, the animals were changed from time to time in order to preclude any one set being more favourably inclined to any special diet. It will be observed that plain bread was preferred to anything else, and it was found more attractive than the staple food-supply in slaughter-houses, granaries, and fat-factories. All mealy substances were liked, especially oatmeal. With regard to fats, lard and dripping were seldom taken, but tallow was readily eaten. Contrary to the statements in many books on the subject of rat-destruction, meat, except tripe, and fish, even when smoked, were only accepted when no other food was available.

Food faintly flavoured with oils of Rhodium and Aniseed, instead of improving the bait, had the contrary effect.

Although the Black Rat (*Rattus rattus*) is supposed to have a predilection for a fruitarian diet, this was not the case with the individuals we experimented upon, their tastes not differing from those of the Common Brown Rat (*Rattus norvegicus*), bread and other mealy substances being always preferred to fruit and vegetables. The results of the tests on the rats in captivity and on those living in freedom being almost identical, they have been tabulated together. The percentages given below are based on the ratio between the attractiveness of the various baits and plain bread—the favourite food, which is represented by the figure 100:—

Bread (plain)	100
Do. (faintly flavoured with Rhodium)	40
Do. (faintly flavoured with Aniseed)	30
Do. (soaked in milk)	60
Flour and Water	50
Oatmeal	80
Barley	50
Oats	50
Maize	20
Lentil Meal	10
Malt	20
Potatoes (raw)	10
Do. (mashed with milk)	20
Apple	0
Cabbage	20
Banana	60
Tallow	70
Dripping	20
Lard	10
Raw Meat	0
Tripe	50
Bacon	10
Beef Extract	10
Fish (fresh)	10
Do. (smoked)	20
Bloater Paste	30
Sugar	0

Poisons.

Where rats are present in very large numbers under conditions which precluded gas being used, poisoning was found to give the most satisfactory results. Although the use of poisons involves less trouble and expense than gassing and trapping on a large scale, there has been much objection to the method owing to the danger to man and domestic animals, and to the possibility of the rats dying under floorings. With regard to the first objection, the danger has perhaps not been much exaggerated, for although we have ourselves had no such unfortunate experiences, we have heard of numerous cases where pigs and other valuable animals were killed in addition to the rats as a result of treatment with phosphorus, arsenic, and strychnine. As to the second objection, in the course of our numerous tests, conducted both in urban as well as rural districts, we did not receive a single complaint with respect to rats dying under the floorings of buildings, and the possibility of this occurring appears to be more remote than has been suggested.

We spent some time experimenting with both Phosphorus and Arsenic, but it was realized from the first that the dangerous nature of these poisons, unless they proved of very exceptional value, precluded their being recommended for general use. Phosphorus, although obviously easy to detect, proved to be an attractive bait, and far more so than arsenic; unlike the latter, however, it does not, especially in summer, retain its toxic properties for more than a few days.

Below are given tables showing the results of our tests and investigations with phosphorus and arsenic preparations of various kinds. In these, and in our tests and investigations with other poisons, we have termed the result a "Success" where a definite reduction in the number of rats was recorded. In the cases marked with an asterisk we were not present at the test, but the facts were ascertained from reliable witnesses.

Phosphorus.

Nature of Premises or Locality.	Approximate amount of Bait used.	Result.	Remarks.
1. Military Camp and Farm.	15 lbs.	Success.	A very large number of dead rats were collected on the day following the test. This, a very badly infested area, was almost completely cleared of the vermin.
2. Farm.	2 lbs.	Success.	Reduction in number of rats was recorded.
3*. Gardens.	2 lbs.	Success.	The rats were entirely eliminated. This Garden had been treated for a couple of months previous to the test with Virus, but with no result.
4*. Farm.	3 lbs.	Success.	A reduction in the number of rats resulted.
5. Part of Small Town.	10 lbs.	Failure.	Although this town was badly infested only a minute quantity of the poison was taken. Subsequent treatment with extract of Squills was a success.
6. Rubbish Dump.	5 lbs.	Success.	A number of dead rats were collected on the day following the test.
7. Shop.	2 lbs.	Failure.	The bait was not taken.

Arsenic.

Nature of Premises or Locality.	Approximate amount of Bait used.	Result.	Remarks.
1. Private Residence.	2 lbs.	Success.	The rats vanished for a period of 3 or 4 weeks, after which they reappeared but in small numbers.
2. Rubbish Dump.	4 lbs.	Failure.	Only a small quantity of the bait was taken and no dead rats were discovered.
3. Baker's shop.	3 lbs.	Failure.	Although most of the bait disappeared no reduction in the number of rats was recorded.
4. Rubbish Dump.	10 lbs.	Success.	Most of the bait was taken on this occasion and a large number of dead rats were collected.
5. General Stores.	4 lbs.	Failure.	The bait was not taken.

With Strychnine, which is acknowledged a most effective poison, we made no experiments, as, owing to its deadly action, its wholesale use could not under any circumstances be recommended.

Much time was spent testing various preparations of which Barium Carbonate formed the basis, this rat-poison having been selected as the most suitable by the United States Department of Agriculture and the Indian Government. Although 1½ or 2 grains suffices to kill a rat, Barium Carbonate is more or less harmless to domestic animals, cats and chickens withstanding 10-15 grains, and an average-sized dog over 100 grains. It has also the advantages of being cheap, tasteless, and therefore easily made attractive by mixing with a suitable bait: further, its corrosive action on the mucous membrane of the stomach induces the rats to leave their holes in search of drink. Although the successes obtained with Barium Carbonate were not so decisive as those resulting from treatment with Squill—a poison we refer to later,—with one exception a definite reduction in the number of rats resulted from our tests, and we satisfied ourselves that it was as effective as the more dangerous poisons, such as phosphorus and arsenic. In most cases the poison was put down with tallow-fat mixed in equal proportions, and smeared on bread. To make certain of the destruction of all the rats leaving their holes in search of water it was found advisable to place within their reach, on the day following the treatment, bowls containing a solution of squill and milk; the rats being thus made to partake of more poison in their efforts at relief.

Barium Carbonate.

Nature of Premises or Locality.	Approximate amount of Bait used.	Result.	Remarks.
1. Surgical Gut Store.	2 lbs.	Success.	All the bait was taken and the rats disappeared for a month.
2. Ditto.	2 lbs.	Do.	As the rats returned treatment was again applied in the store which was once more cleared.
3. Sweet Factory.	2 lbs.	Failure.	No definite improvement was recorded, although nearly all the bait was taken.
4*. Garden.	1 lb.	Success.	The rats disappeared entirely for a couple of months.
5. Knacker's Yard.	5 lbs.	......	These premises were so seriously infested that a clearance was out of the question, the yard being strewn with bones to a depth of 6 feet. The rats were to be seen in enormous numbers in the daytime. All the bait was immediately taken.
6. Canteen.	1 lb.	Success.	A decrease in the number of rats was recorded.
7. Granary on Wharf.	5 lbs.	Success.	Do.

Other preparations which we tested contained Plaster of Paris, Magnesium Sulphate, Croton, and Squill. With the exception of the last-named we found that all these, however attractively disguised, were only taken if no other food was available, and their use as a raticide could therefore be disregarded. Squill, which is obtained from the bulb of a plant (*Scilla maritima*) occurring in great abundance on the Mediterranean coasts, can be used either in the form of a powder or of a solution, and in France and its Colonies it has for some years been known to be an effective rat-poison. In this country it has been little used, as until quite recently the only proprietary preparations containing the extract of the plant have been in the hands of companies which likewise sold virus, and its use was only recommended in the event of the virus proving a failure. Although extremely toxic as far as rodents are concerned—the minimum lethal dose for a rat being only half a grain—Squill is comparatively harmless to domestic animals.

As will be seen below, a very large number of tests were made with Squill preparations, some in the liquid, others in the powder form. In the liquid form the Squill was mixed with an equal proportion of milk into which 8 lbs. of bread were soaked for every gallon of the solution. As a powder it was given mixed with tallow, or tallow and oatmeal, and smeared on bread. With one exception, however, our successes were obtained when the liquid Squill was mixed with bread and milk, and it is in this form that we recommend its use.

Squill.

Nature of Premises or Locality.	Approximate amount of Bait used.	Result.	Remarks.
1. Store.	2 lbs.	Success.	This store, in which the rats were to be seen in broad daylight, was very badly infested, and for 3 months previous to our test an average of 50 rats a week were caught with traps. As a result of the treatment a large number of dead rats were discovered and the store was entirely cleared of the rodents.
2. Farm.	10 lbs.	Success.	A number of dead rats were collected in the course of the week following the treatment, and a diminution in their numbers was recorded.
3*. Private Residence.	1 lb.	Success.	The rats were entirely cleared from the premises.
4. Part of Town.	20 lbs.	Success.	A number of dead rats were collected on the day following the application, and a diminution in their numbers was recorded. This town had previously been treated with virus and phosphorus with no results.
5. Poultry Yard.	3 lbs.	Success.	A decrease in the number of rats was recorded, and a number of carcasses were found on the premises on the day after the poison had been put down.
6. Poultry Yard.	2 lbs.	Success.	No rats have been seen in this yard since the test was made. Virus had previously been used without success.
7. Farm.	20 lbs.	Success.	This farm was very badly infested, and the rats were in evidence in large numbers in the daytime. The day following the treatment a very large number of carcasses were collected. The farm is now comparatively free of the vermin.

Nature of Premises or Locality.	Approximate amount of Bait used.	Result.	Remarks.
8. Garden.	3 lbs.	Success.	Large number of dead rats found in the week following the treatment. A great improvement was effected.
9*. Farm.	8 lbs.	Failure.	The bait was not taken.
10. Farm.	8 lbs.	Success.	A number of dead rats was collected on the day following the treatment, and a diminution in their numbers was recorded.
11*. House and Stables.	4 lbs.	Failure.	The bait was not taken.
12. Town.	150 lbs.	Success.	This test proved a great success, dead rats being found in very large quantities in all parts of the town on the two days following the treatment. The rats have been practically exterminated.
13. Embankment.	4 lbs.	Success.	The rats were entirely cleared from this embankment.
14. Residence.	2 lbs.	Failure.	Only a very slight diminution in the number of rats was recorded.
15. Food Store.	4 lbs.	Failure.	Most of the bait was taken, but no good results were obtained.

In tests numbers 13, 14, and 15 squill-powder was laid down. In all other cases the solution was used.

As a result of our investigations, we have no hesitation in coming to the conclusion that Squill-solution is the most effective rat-poison, and recommend its use in preference to Barium Carbonate for the following reasons:—

(1) That for rodents it is three times as toxic.
(2) That it is even less harmful to most domestic animals.

The one point against the use of Squill lies in the fact that at present it is somewhat more expensive than most other poisons. The plant grows, however, in extraordinary abundance on both the African and European coasts of the Mediterranean, and therefore no difficulty should be experienced in obtaining a large supply at a reasonable cost.

Virus.

The discovery some time back of a bacillus pathogenic to rodents led to a new method for the destruction of rats and mice. Following this discovery, the virulence of the organism was raised by artificial methods in the laboratory and a number of Rat Viruses were placed on the market.

The manufacturers of these claimed that the bacillus was so virulent that it would kill rodents in about ten days, and that within a month the disease would spread with fatal results to the whole of the rat—or mouse—population of the area under treatment. The results of recent investigations on the efficiency of some of the viruses on the market have been disappointing. Bainbridge* has experimented on a very large number of rats in captivity, and the results of his experiments showed that the destructive power of all the viruses he tested was inconstant, the death-rate in the different experiments varying from 20 to 50 per cent. Further, according to this experimentator the presence of agglutinins in the serum of the rats which survived after being fed on virus gave reason to suppose that a certain proportion acquired immunity and were therefore unlikely to succumb to a second infection.

Experiments with the rat-viruses conducted some years ago during the outbreak of plague in San Francisco also gave poor results.

It must be recognized that, if generally successful, this method of exterminating rats and mice by spreading among them a disease, not affecting Man and domestic animals, could not be improved upon, and I was therefore anxious to give a thorough test to all the viruses on the market in the hope that the results of the experiments under natural conditions would differ from those obtained in the laboratory.

We made in all 7 tests with different virus preparations, and of these one only was an unqualified success; three were partial successes, a very slight reduction in the number of rats being recorded, and three were absolute failures. A number of reliable witnesses who visited the Exhibition in the course of the summer informed us of their experiences, and we ascertained the successes in these cases to amount to about 33 per cent.

Trapping.

Although we found that trapping alone will not always rid us of the rats where they are present in very large numbers, nevertheless if the best traps are used skilfully and persistently the vermin can be greatly reduced. Owing to the abundance of food in our Gardens, the locality is not one where much success would be expected. Nevertheless, in the four months referred to in this report, we caught with traps alone 736 rats. Of the many different traps laid down, three types accounted for 85 per cent. of the total catch. Some of the traps that proved to be failures were those we found most frequently in use in the rat-infested localities which we visited, while the most successful type of trap, several of which had been laid down in our Gardens for several years, is now, so far as we can make out, no longer being manufactured. The latter trap, known to us as the Brailsford Trap, consists of a long, narrow wire cage with doors at each end, which, when the trap is set, remain open, leaving a direct passage through. A platform in the centre, where the bait is placed, is connected by a spring which when trodden upon releases the doors, imprisoning the rat or rats. Such traps were put down on 687 occasions and accounted for the capture of 209 rats. Two makes of this trap were formerly sold, the one in which the height of the passage measured $4\frac{1}{2}$ inches, the other in which it measured 7 inches. As the latter gave far better results than the former, in order to ascertain the proportions which would give the best results, traps of different height and width were tested, with the result that the type with the greatest height was found most successful.

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* Journal of Pathology, vol. xiii. 1909.

The following are particulars of these tests :—

Percentage of rats caught in traps	$4\frac{1}{2}''$	high	19.
,, ,, ,, ,,	$7''$	,,	28.
,, ,, ,, ,,	$8''$	,,	34.

The width, provided it allows for the free passage of the rat, makes no difference.

Other cage-traps tested included such well-known types as the ordinary Cage Trap with bait hook, and with a platform connected by a spring with the door, the Eelpot or Wonder, the Round Wire, and the "Mysto." We also experimented with a number of new types sent to us, and with Barrel traps and Stockades.

The ordinary Cage Trap.—This trap, which is sold at most ironmonger shops, we saw in use on many occasions in the course of our visits to rat-infested localities, but were invariably informed that it caught no rats. This was likewise our experience with the type without the bait-hook. When, however, it was provided with the platform which when trodden on closed the door, more satisfactory results were obtained, 16 rats being caught with 166 of these traps.

The Eelpot or Wonder Trap, which permits the free entry of the rats whilst preventing their exit, is divided into two compartments connected with a trap-door. This trap has, I know, frequently been responsible for the capture of numbers of rats. With us it did not prove a great success. The keeping of a female in the trap and baiting with the female genital organs having been said to entice the males, both these devices were resorted to, but with negative results.

The Round Wire Trap is a simple type, the rats having an entry through a hole in the centre, but being prevented from escaping by the presence of a number of fine loose wires which hang from the sides of this aperture and close round the hole when the rat climbs up in order to escape. For some weeks we placed one of these traps, measuring 9½ inches in height, in various localities in the Gardens frequented by the rodents, but without success. At a later date we found that this type was being used with good results in a rat-infested store, and on comparing it with the one we had been using found that it differed in measuring only 7 inches in height, and a similar one was procured for our use. If not very successful it nevertheless caught a number of rats, and obviously therefore, as was the case with the Brailsford trap, it proved specially efficacious only when conforming to certain measurements. With 124 traps of this kind (7 inches in height) 12 rats were captured.

The "Mysto" Trap consists of a metal structure connected with a tank full of water. The bait is placed just inside the door, which closes on the entry of the rat. In order to effect its escape the rat climbs up the cage to a hinged platform, which collapses, precipitating the rodent into the tank. The collapse of this platform automatically opens the door of the cage and the next rat is thus enabled to enter and repeat the performance. Although I have been informed by some users of this trap that it gave good results, the one which we tested for several weeks was responsible for the capture of one rat only.

A number of new types of cage-traps were sent us and given a trial. Some were most ingenious, but as they failed to catch rats it is unnecessary to allude to them.

It was found that several of the cage-traps we tested were made of too light wire, with the result that the captured rats were able to force the wires apart and escape.

Barrel traps have frequently been asserted to be very effective, and we therefore experimented with these both in the Gardens and in other localities where rats were numerous. One of the methods we employed was to fill the barrel up to within a foot of the top with earth, covered with sawdust and chaff, and upon this placed various bait. For some days we allowed the rats to feed from the barrel. When we found that most of the bait had been taken for several nights in succession, water was substituted for the earth, also covered with a layer of sawdust and chaff; and we awaited results. None were, however, forthcoming, the rats obviously suspecting a deception. The other method consisted of covering the barrel with brown paper, upon which the bait was placed. After the food had been taken for a few days a cross was cut in the paper in order that the rats might fall through into the barrel. This answered very much better, and a number of rats were captured by this device.

The ordinary Stockade trap consists of a wooden stockade about 4 feet high constructed to enclose a space about 10 feet square. On one side is a door a foot wide and high, which is open and closed by a cord and pulley. The Stockade having been baited and the door kept open, the rats are for a week or so allowed to feed and to run in and out. Subsequently the operator secretes himself and at a suitable moment releases the cord controlling the door. This contrivance having proved a success we were anxious to give it a trial. The weak part, however, of this trap appeared to be the amount of time that would be wasted by the man controlling the sliding-door, and therefore, in order to dispense with the human element, with the help of my friend Mr. Mark Barr, I worked out a scheme which enabled the open door, which rested on a hinge, to fall by being drawn towards an electro-magnet, the latter being in contact with a number of batteries and an alarm-clock. Thus if we wished the door of the trap to be shut at a certain time all that was necessary was to set the alarm for that time, when the current acting on the magnet released the door. With this a number of rats were captured. During the winter months, when less food is available, it may possibly give still better results.

The steel Gin trap has for years been used with success, and is the type generally popular with the gamekeeper. Nine hundred and seventy-three of these traps laid down in our Gardens were during the four months in question responsible for 173 rats, a percentage of 17. Considering that we obtained a higher percentage with the Brailsford trap, we presumed that the gins would be specially successful if laid in the centre of any passage showing light at the far end, and we consequently experimented by covering them with large drain-pipes cut longitudinally in half. This experiment was, however, a failure. At a later date we continued the experiment on the same lines and had holes bored in the top of the pipes in order to allow for some light to enter. This was slightly more successful than when the middle of the pipe was in complete darkness, and a few rats were caught. The results, however, could not compare with those obtained when the traps were put down in the usual manner. As the Brailsford traps continued to give such satisfaction, I ordered a number of covers exactly similar to those of the cage-trap, but without doors, bottom or centre platform, in order to ascertain whether, when the gin-traps were covered with these wire-passages, a higher percentage of successes would be attained. The result was highly satisfactory, the gins, when placed under these cheap wire-covers catching almost as many rats per trap as the Brailsford and a higher number than when placed in runs in the ordinary way.

Break-back traps.—With one exception these gave no good results. The exception was a type known as the "Nipper," and with 1962 of these traps 237 rats were caught. This, a very inexpensive trap, is most suitable for putting down indoors or under cover, as in wet weather the wood is liable to warp and render the appliance useless. We would suggest to the makers that a similar trap be made of metal for outdoor use. As in the case of the Gin traps, the "Nippers," when placed under wire-covers, were responsible for a higher percentage of captures. The figures below show results obtained with 100 Gin and 100 Nipper traps when laid down in the ordinary manner and placed one of these traps, measuring 9½ inches in height, in various localities in the Gardens frequented by the rodents, but without success. At a later date we found that this type was being used with good results in a rat-infested store, and on comparing it with the one we had been using found that it differed in measuring only 7 inches in height, and a similar one was procured for our use. If not very successful it nevertheless caught a number of rats, and obviously therefore, as was the case with the Brailsford trap, it proved specially efficacious only when conforming to certain measurements. With 124 traps of this kind (7 inches in height) 12 rats were captured.

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Number of rats caught with 100 Gin traps laid down in the ordinary manner	19
Do. do. 100 Nipper traps do.	14
Do. do. 100 Gin traps covered with wire tunnels	28
Do. do. 100 Nipper traps do.......	21

An additional advantage in the use of these wire covers lies in the fact that the Gin and Break-back traps can be laid down in poultry-runs without fear of injury to the full-grown birds.

It having constantly been stated that traps should be handled as little as possible, and that in setting them gloves should be worn or the hands rubbed in earth, we experimented with a very large number of traps to ascertain whether rats are really influenced by the human odour and are alarmed thereby. On fifteen occasions we laid down in a rat-infested locality outside the Gardens 20 traps, 10 Gin traps and 10 Nipper traps, half of these being carefully handled with gloves rubbed in earth and faintly scented with aniseed, the other half being freely handled with the naked hand. As a result of this experiment we satisfied ourselves that there is no necessity for attempting to disguise the human odour, 36 rats being caught with the traps handled in the ordinary way and only 31 with those laid down with gloves.

The following table shows the number and type of traps laid down between the months of April and September with the percentages of captures:—

Type.	Number of Times set.	Number of Rats caught.	Percentage.
Brailsford Trap (all sizes).................	687	209	33
Gin Traps	973	173	17
Do. (placed under wire tunnel) ...	135	36	26
Nipper Traps	1962	237	12
Do. (placed under wire tunnel).	126	24	19
Round Wire Trap (7″ high)..............	124	12	10
Do. (9½″ high)	61	0	0
Ordinary Cage Trap (with bait hook only)	82	0	0
Do. (with platform) .	166	16	10
Eelpot or Wonder Trap....................	195	17	9
Other types	528	12	2

Hunting with Dogs and Ferrets.

Although this method is practically useless in most towns, it is of the greatest assistance in keeping down the rat population in the country. A good ratting dog seldom fails to locate the presence of a rat, and will always differentiate between the inhabited and uninhabited holes. The results obtained when ferrets co-operate with a dog are usually very satisfactory, and such hunts with sticks and shot-guns in the Society's Gardens, in conjunction with trapping, has led in the past few years to a very distinct reduction in the numbers of rats, in spite of the general increase elsewhere. The time spent on rat-hunting with the help of dogs and ferrets has during the months of April to September averaged eight hours a week and has resulted in 340 rats being killed. Like trapping, hunting with dogs and ferrets should be pursued with special activity during the winter months, and during the periods following poisoning with Squill or Barium Carbonate.

Gassing.

This method has the distinct advantage over all others in that it kills not only the adult rats but also the newly-born in their nests. The gases most frequently advocated for rat-destruction are Carbon Bisulphide, Hydrocyanic Acid, and Sulphur Dioxide. Although both Carbon Bisulphide and Hydrocyanic Acid are very effective, the dangerous nature of these gases, the former being highly inflammable and explosive, and the latter very poisonous, odourless, and invisible, makes it impossible to recommend their use. Sulphur Dioxide, however, is visible and non-inflammable, and harmless to man when inhaled in small quantities.

In the course of this summer we were afforded opportunities of being present at fumigations by means of sulphur candles, and an apparatus manufactured by the Clayton Fire Extinguishing and Disinfecting Company, in which the sulphur is burned in a furnace supplied with air induced by a draught, and the gas driven off under pressure through a hose.

The use of the candles for killing rats in their burrows we found ineffective, the gas penetrating too slowly; when the sulphur dioxide is, however, driven into the holes under pressure the whole network of runs is permeated in a few seconds, making the existence of the rats underground impossible. Although many of the rodents escape only to die in the open, some no doubt recover, and the co-operation of a dog is therefore desirable. The large Clayton machines which are used for fumigating ships and large buildings are driven by petrol or electricity. I was shown, however, the model of a new portable hand-driven apparatus which appeared suitable for the treatment of hedges and embankments. No opportunity was afforded us of witnessing gassing on ships with these machines, but we were able to investigate the system of rat destruction by means of sulphur candles as employed by the Port of London Authority. The method gives very satisfactory results and could not we think be improved upon.

Preventive Measures.

The chief preventive measures, such as the protection of food supplies, the destruction and prompt removal of garbage, the repairing of defective drains, and the rat-proofing of buildings, have been preached so consistently of late that it is unnecessary to allude to them further. It must remain with the medical officers of health and other sanitary authorities to see that these conditions are enforced.

Protection of Ricks.

The building of ricks on rat-proof platforms has been officially recommended. These platforms, however, besides being extremely costly are not easily portable, and as the ricks are annually erected on different sites, this method of protection can only be adopted in rick yards. It has been found by experiment, which we have confirmed, that rats will not dig to a depth of more than 2½ feet, and therefore all that is needed is to surround the ricks with galvanized iron sheets, 5½ feet high, dug slightly over 2 feet into the ground. The cost of such an erection would amount to less than half that of a platform. The sheets are portable and would last for many years.

Increase in the numbers of the Old English Black Rat.

We ascertained in the course of our investigations that not only had the Common Brown Rat very greatly increased in numbers in recent years, but that since 1910 the Old English Black Rat had become much more abundant, and in London both species are now in some parts living in harmony, not only on the same premises but in the same rooms. On the one floor of a factory in Holborn we captured both species of rats, and also specimens of the Alexandrine Rat—the brown variety of *Rattus rattus*, and the black variety of *Rattus norvegicus*. A well-known London rat-catcher, who has kept records of his captures, informs me that he is at the present time catching as many Old English Black Rats as Common Rats in localities where, prior to the war, the latter only were found.

This recent increase in the numbers of the Old English Black Rat is disquieting, and can only be checked by the enforcement of stricter measures for their destruction on incoming vessels.

15. On certain Features of the Otic Region of the Chondrocranium of *Lepidosteus*, and Comparison with other Fishes and Higher Vertebrates. By Edward Phelps Allis, Jr., F.Z.S.

[Received May 6, 1919: Read May 27, 1919.]

In a figure of a 149 mm. specimen of *Lepidosteus osseus*, Veit ('07) shows the larger part of the dorso-lateral edge of the otic portion of the chondrocranium formed by a laterally projecting ridge which he says is currently called the crista parotica, and he adopts this name for it. It will, however, be later shown that the anterior portion of this ridge is not included in the crista parotica of current descriptions of mammalian embryos, and there is some doubt as to any part of it being the strict homologue of that crista. The name is therefore inappropriate, and as the ridge lies, in fishes, in part on the sphenotic and in part on the pterotic portion of the chondrocranium, I shall call it the spheno-pterotic ridge.

The sphenotic portion of this spheno-pterotic ridge is formed, in Veit's 149 mm. specimen of *Lepidosteus*, by the dorso-lateral edge of the autosphenotic, and it begins, anteriorly, at the summit of the postorbital process. Its pterotic portion is wholly of cartilage, but it supports, in this fish as in *Amia*, the lateral edge of the dermo-pterotic. The anterior three-quarters, approximately, of this cartilaginous portion of the ridge forms the dorsal edge of the articular facet for the hyomandibula, and, as shown in the figures given, it apparently lies along the dorso-lateral edge of the ridge of the lateral semicircular canal. At the hind end of the facet for the hyomandibula the ridge is joined by a much less pronounced one, which forms the ventral edge of the facet for the hyomandibula, the two ridges, united, then continuing onward a short distance as a stout and rounded ridge, which lies along the lateral, instead of the dorso-lateral, surface of the ridge of the lateral semicircular canal and ends somewhat abruptly with a curved hind edge slightly posterior to the anterior edge of the epiotic bone and some little distance anterior to the transverse plane of the vagus foramen. The marked, postero-laterally projecting corner at the hind end of this ridge of *Amia* (Allis, '97, fig. 8) is thus wanting in *Lepidosteus*, but the ridges of these two fishes must, nevertheless, have approximately the same posterior extent, for the hind end of the ridge is traversed in each of them by a canal which transmits the ramus dorsalis of the nervus glossopharyngeus.

Along the lateral portion of the dorsal surface of the chondrocranium there is a sulcus longitudinalis, which is bounded laterally by the spheno-pterotic ridge and mesially by a ledge, the rounded edge of which lies at a much higher level than the spheno-pterotic ridge and in the line prolonged of the lateral edge of the epiotic bone. The lateral portion of this sulcus lodges that thickened lateral portion of the dermopterotic that is traversed by the main latero-sensory canal, and its deepest portion lies between the ridges of the anterior and posterior semicircular canals. The sulcus runs posteriorly over the hind edge of the ridge of the lateral semicircular canal, and is there in communication, across the ridge of the posterior semicircular canal, with a slightly depressed region which lies directly beneath the overhanging lateral edge of the epiotic and extends ventrally to the dorsal edge of the vagus foramen. This depressed region doubtless lodges a part of the thymus, for, in an 80 mm. specimen of this fish, I find a large anterior portion of that gland lying close against the cranial wall, immediately postero-lateral to the descending limb of the posterior semicircular canal, and having a small dorso-anterior prolongation which passes upward postero-mesial to the levatores arcuum branchialium and the adductor and levator operculi, at their insertions, and then over the hind edge of the spheno-pterotic ridge on to the dorsal surface of its hind end.

The depression for the thymus, above referred to, is separated from the posterior surface of the chondrocranium by a sharp ridge, which Veit calls the crista occipitalis lateralis, this name evidently having been adopted from Gaupp's ('93) descriptions of *Rana*, where the so-designated ridge is said to be a band of cartilage which forms the dorsal boundary of the vagus foramen, and connects the otic capsule at the middle of its height with the dorsal end of the occipital arch. The crista of *Lepidosteus* is thus not the exact homologue of the crista of *Rana*, and would seem to be a ridge secondarily developed upon that crista. It forms the boundary between the dorsal and lateral surfaces of the occipital portion of the chondocranium, and lies in *Lepidosteus* as in *Rana* wholly upon the os occipitale laterale (exoccipital), but in many of the Teleostei the corresponding ridge lies as much upon the basioccipital, opisthotic, and pterotic as upon the exoccipital. In *Lepidosteus* it is said by Veit to vanish, anteriorly, on the roof of the labyrinth region of the cranium, but it is not so shown in his figures, there running directly into the ventro-posterior edge of the epiotic bone, but separated from that bone by a narrow space which has the appearance of being a notch in the edge of the ridge. The epiotic forms the dorso-postero-lateral corner of the chondrocranium, and apparently has no relations whatever to the ridge of the posterior semicircular canal, for it is shown lying definitely postero-mesial to the prominentia canalis semicircularis posterioris. Veit says that he could find no indication whatever of the epiotic being formed of two components, an epiotic and opisthotic, as described by Parker ('82) in embryos of this same fish. An opisthotic bone is, in any event, wholly wanting in this fish, as is also, even in the adult, an autopterotic.

In a 20½ mm. embryo of this fish, Veit ('11, fig. 18, pl. c.)

shows, on the dorsal surface of the otic capsule, a marked depression, which corresponds to that portion of the sulcus longitudinalis of the 149 mm. specimen that lies posterior to the ridge of the anterior semicircular canal. This supraotic depression opens posteriorly, across the posterior portion of the ridge of the lateral semicircular canal, between that ridge and the ridge of the posterior semicircular canal, on to the lateral surface of the chondrocranium, and a slight depression leads from its dorso-mesial edge across the ridge of the posterior semicircular canal into a depression which lies postero-mesial to the latter ridge, between that ridge and the bounding edge of the foramen magnum. This latter depression is called by Veit the fossa supratemporalis, and it corresponds to the postero-ventral prolongation of the supratemporal groove of my descriptions of *Scomber* (Allis, '03). There is in this embryo no epiotic process in any way comparable to that in the 149 mm. specimen, but the basal portion of that process must be represented in the summit of the ridge of the posterior semicircular canal, for, in my 80 mm. specimen of this fish, I there find the epiotic already represented by a thin layer of perichondrial bone. The strongly developed epiotic process of the 149 mm. specimen must, therefore, have been formed by the addition, to this perichondrial bone, of bone of membrane origin.

The so-called crista parotica of this embryo is said by Veit ('11, p. 168) to be a ridge which forms an anterior prolongation of the ridge of the lateral semicircular canal ("springt in ihrer Fortsetzung eine scharfe Leiste lateralwärts vor"), and it ends, anteriorly, at the summit of the postorbital process. The anterior portion of the ridge is said to be perforated by a canal which lodges the recessus dorsalis spiracularis, this part of the ridge thus having no relations whatever to the ridge of the lateral semicircular canal. The posterior portion of the crista is said to form the dorsal edge of a small oval depression which apparently occupies the full width of the ventral surface of the ridge of the lateral semicircular canal, and Veit calls this entire depression the articular facet for the hyomandibula.

In a 20 mm. embryo of this fish, examined in serial transverse sections, I find a longitudinal depression which has exactly the position of the so-called facet for the hyomandibula of Veit's 20½ mm. embryo, but the hyomandibula, which is thin, articulates with the dorso-lateral quarter only of this depression, there lying immediately beneath the spheno-pterotic ridge (Veit's crista parotica). The ventro-mesial edge of the depression is formed by a slight ridge, which gives insertion to the adductor hyomandibularis, this ridge forming the dorsal edge of a groove which lies between it and the bulla acustica and lodges the vena jugularis. Between this slight ridge and the hyomandibula there is a large lymph vessel which, at the hind edge of the adductor hyomandibularis and anterior to the levatores arcuum branchialium, separates into two parts, one running ventrally along the lateral surface of the cranium to join and accompany the vena jugularis and the other running outward and ventrally, internal to the opercular bones, into the gill-cover. Posterior to the adductor hyomandibularis, the ridge that forms its surface of insertion gradually vanishes along the ventro-lateral surface of the ridge of the lateral semicircular canal, and, posterior to the ridge, the levatores arcuum branchialium and the adductor and levator operculi have their insertions at a higher level, immediately ventral to the hind end of the spheno-pterotic ridge, or even posterior to that ridge. In my 80 mm. specimen the hyomandibula is much stouter than in the 20 mm. one, and a definite ridge there forms the ventral edge of its articular facet, this ridge lying at about the middle of the depression described in the 20 mm. embryo, and corresponding to the ridge that forms the ventral edge of the facet in Veit's 149 mm. specimen.

In a 14 mm. embryo of *Lepidosteus* the so-called crista parotica is said by Veit ('11) to be a short ridge which forms the ventral border of the foramen by which the ramus oticus lateralis issues on the dorsal surface of the chondrocranium, and it is shown in the figures given lying anterior to the anterior edge of the articular facet for the hyomandibula, and separated from it by a depressed region which probably lodges the recessus dorsalis spiracularis. The ridge lies between the transverse planes of the trigeminus and facialis openings of the trigemino-facialis chamber, and, as the lateral wall of that chamber is formed by the otic process of the palato-quadrate (pars ascendens quadrati), the crista parotica is a ridge that lies approximately along the line where that process fuses with the cranial wall. The so-called crista parotica of this embryo and the ridge that forms the dorsal edge of the articular facet for the hyomandibula thus have similar relations to structures derived, respectively, from the branchial-ray bars of the mandibular and hyal arches (Allis, '18). The articular facet for the hyomandibula is said to lie, in this embryo, on the ventral surface of the prominentia ampullæ lateralis, and its dorsal edge is not referred to as a part of the crista parotica. In 11–12 mm. embryos the hyomandibula is said to be here fused with the wall of the otic capsule.

The spheno-pterotic ridge of *Lepidosteus*, the crista parotica of Veit's descriptions, is thus a ridge which apparently has two distinctly different parts, which are related, respectively, to the dorsal ends of the branchial-ray bars of the mandibular and hyal arches. The ridge is of relatively late ontogenetic development, and there is nothing in the descriptions of this fish to warrant the assumption that either of its two parts has been developed primarily in special relation to the related branchial-ray bar. Veit's conclusion ('07, p. 179) that the entire ridge has been developed in relation to the articulation of the hyomandibula with this part of the cranial wall is, furthermore, evidently incorrect, for the hyomandibula of his 149 mm. specimen lies, approximately, beneath the two middle quarters only of the entire ridge.

The ridge forms the bounding edge between the dorsal and lateral surfaces of the chondrocranium, and it may be that it has developed for this particular purpose, but there is the evident suggestion that it has been developed in some relation to the main latero-sensory canal, for that canal always lies parallel to and slightly mesial to it, and the lateral edges of the dermal bones that later enclose that canal are always supported by it. The relations of the ridge to the ridge of the lateral semicircular canal are then simply fortuitous. The ventral edge of the so-called facet for the hyomandibula of Veit's 20½ mm. embryo corresponds to the opisthotic ridge of my descriptions of *Amia*, *Scomber*, and the Mail-cheeked Fishes, and has no relations whatever to the articular facet for the hyomandibula.

In the prepared skull of a large specimen of *Lepidosteus platostomus*, I find the slightly depressed region which, in Veit's 149 mm. specimen, lies immediately posterior to the hind end of the spheno-pterotic ridge, as an irregular and relatively deep fossa which lies mostly on the lateral surface of the cranium but partly also on its posterior surface, the ventral portion of the fossa cutting across the dorso-anterior end of the lateral occipital ridge and its dorsal portion, which has pit-like depressions in its floor, extending upward mesial to the hind end of the spheno-pterotic ridge. The lateral occipital ridge lies wholly on the exoccipital, ending at the dorsal end of that bone, and mesial to its dorso-anterior end an entirely independent ridge begins, and, lying wholly on the epiotic, runs dorso-anteriorly toward the summit of that bone. This latter ridge is thus the homologue of the epiotic ridge of my descriptions of *Amia*, *Scomber*, and the Mail-cheeked Fishes, and the lateral occipital ridge is the homologue of that part of the lateral occipital ridge of the latter fishes that lies ventral to that process of the opisthotic that gives articulation to the pedicel of the suprascapula.

In the prepared skull of a much smaller, but still adult specimen of *Lepidosteus osseus*, somewhat similar conditions were found; but in a second specimen of this fish, not previously dissected, the lateral occipital ridge was found continuing upward on to the ventral surface of the overhanging epiotic process, but there double, the postero-mesial portion of the ridge corresponding to the independent epiotic ridge of the other specimen. In this second specimen there is a short but well-defined groove on the lateral surface of the chondrocranium, anterior to the dorsal end of the lateral occipital ridge. This groove lies external to the hind end of the lateral semicircular canal, in the hollow between that ridge and the ridge of the posterior semicircular canal, is seen in posterior as well as lateral views of the cranium, and leads dorsally into the hind end of the supraotic depression. It evidently corresponds to the ventro-posterior continuation of the temporal groove of *Amia*, *Scomber*, and the Mail-cheeked Fishes, but in *Lepidosteus* it lodges a part of the thymus, and it is unquestionably this gland that is the cause of the marked differences in the grooves of different specimens of this fish, and of the irregularities in the epiotic and lateral occipital ridges. A stout tendon arises from the hind end of the spheno-pterotic ridge, and, running posteriorly, at first lateral to the thymus but later enveloped in that gland, gives insertion to an anterior extension of the trunk-muscles; this tendon thus representing the stout posterior process of the teleostean pterotic, which is wanting in *Lepidosteus*. This tendon spreads posteriorly, and a part of it is inserted on a ventral process of the suprascapula, and another part on the large occipito-supraclavicular ligament; these attachments suggesting the ligament which, in certain of the Teleostei, replaces the pedicel of the suprascapula of others of those fishes. The occipito-supraclavicular ligament is a large tough fascia which arises from a process on the lateral surface of the basioccipital, lies upon the external surface of an anterior extension of the trunk-muscles which has its insertion on the lateral surface of the cranium ventral to the vagus foramen, and is inserted mainly on a process along the internal surface of the lateral edge of the supraclavicula, but partly also on the clavicle. The levator and adductor operculi, and the levatores arcuum branchialium, arise from the cranial wall ventral to the ligament that represents the posterior process of the pterotic, and anterior to the groove for the thymus. A stout aponeurotic formation, which extends ventro-posteriorly into the trunk-muscles, arises from the epiotic process, and that process is evidently developed in relation to it. The epiotic ridge is strongly developed and is certainly largely of membrane-bone, the line of the ridge not even following the line of the posterior semicircular canal, as it does in many of the Teleostei.

There is thus in *Lepidosteus*, as Veit stated, no functional temporal fossa, but there is a supraotic depression which, if invaded by the trunk-muscles through the interval between the epiotic process and the hind end of the spheno-pterotic ridge, would give rise to that functional fossa, and a small anterior extension of the trunk-muscles is in position so to invade it. If the trunk-muscles were to invade it they would evidently tend to deepen it by cutting into the massa angularis from behind and above, and this would give rise to a temporal groove similar to that in *Amia*, which would not, primarily, extend anteriorly beyond the anterior semicircular canal. The development of an autopterotic, and the accompanying reduction of the dermopterotic, would then give rise to the temporal groove of *Scorpæna* (Allis, '09), this groove naturally lying mesial to the line of fusion of the dermo- and auto-components of the pterotic, and hence mesial to the latero-sensory canal that traverses that bone. If the trunk-muscles were then to push forward dorsal to the anterior semicircular canal, the groove of *Scomber* would arise, the anterior prolongation of the groove so formed lying dorsal to the parietal and frontal, being much less deep than its primitive posterior portion, and being separated from that portion by a marked ledge (Allis, '03). A perforation of the mesial wall of this anterior prolongation of the groove would give rise to the conditions described by Ridewood ('05) in certain of the Clupeidæ, this perforation of that wall being called by him the temporal foramen. The foramen is, however, probably simply a fenestra, for, in a single specimen of *Clupea alosa* that I have examined, I can find no nerves or vessels traversing it. It opens directly into the dorsal end of the mid-brain recess of the cranial cavity, and it would seem as if it must be closed by membrane, but no such membrane was evident in my specimen. The pre-epiotic fossa of Ridewood's descriptions of these fishes is simply a depression in the mesial wall of the deeper posterior portion of the entire temporal groove.

A modification of the temporal groove, as above described, occurs when, as in certain of the Teleostei, the massa angularis is excavated from its lateral surface, ventral to and in the hollow of the semicircular canal, to form the subtemporal fossa of Sagemehl's ('91) descriptions. The axis of this fossa lies transversely to that of the temporal groove, and its arched roof forms a transverse ridge across the floor of the latter groove, at about the middle of its length; and when the temporal groove is roofed by dermal bones, and so becomes a fossa, and the subtemporal fossa is extensive, as in certain of the Barbidæ, it practically suppresses that part of the temporal fossa that lies dorsal and anterior to it. The temporal fossa then becomes a large but shallow depression on the posterior surface of the cranium, from which, according to Sagemehl ('91, p. 553), a simple cleft may extend forward between external and internal plates of the pterotic (*Squamosum*, Sagemehl) and represent the anterior portion of the primitive fossa. This cleft is said by Sagemehl to be in large part filled with fatty tissue which contains pigment-cells and a few scattered muscle-fibres, the presence of the muscle-fibres seeming to show that the groove of these fishes was primarily more extensive, and that it has suffered reduction as a result of the development of the subtemporal fossa. In *Albula* (Ridewood, '04) this type of fossa is also found, but the anterior portion of the fossa has not been completely pinched off and suppressed, and the fossa further differs from that in the Barbidæ in that its anterior portion lies beneath the frontal bone, and in that its floor is in part formed by the proötic.

In *Elops* the temporal groove is similar to that in *Albula*, but the trunk-muscles have here pushed forward in the direction of the little recess described by me ('03, p. 51) at the antero-lateral corner of the deeper posterior portion of the temporal groove of *Scomber*. The resulting anterior extension of the temporal fossa of this fish thus lies lateral to the anterior semicircular canal, in the angle between that canal and the anterior portion of the lateral semicircular canal, and ventral, instead of dorsal, to the investing bones on the dorsal surface of the cranium. Its anterior end reaches the alisphenoid region, and is there bounded both laterally and mesially by portions of the alisphenoid bone, the groove thus splitting the dorsal edge of that bone and being lodged between its two parts. In *Albula* the trunk-muscles fill the entire temporal groove. *Whether or not this is also true of Elops* I cannot tell from the remnants that I have of the skull of this fish, but a re-examination of these remnants shows that the anterior semicircular canal is enclosed in the proötic, and not, as stated in my work on the Mail-cheeked Fishes, in the alisphenoid.

In *Catostomus* and *Moxostoma*, the temporal groove is said by Sagemehl ('91, p. 550) to be nearly transverse in position, and to open on to the lateral instead of the posterior surface of the chondrocranium. The epiotic is said to form the posterior boundary of the groove, and the pterotic its anterior boundary; and the mesial portion of the groove is said to be roofed by the epiotic, pterotic, and parietal. It is not said what muscle, or muscles, occupy the groove in these particular fishes, but as no muscle is anywhere mentioned in relation to the groove, in any of the several species of the Cyprinidæ described, excepting only an anterior extension of the trunk-muscles, it is natural to assume that this muscle was considered by Sagemehl to have here invaded it. In *Catostomus*, Sagemehl found a greatly reduced opisthotic, but in *Moxostoma succetta* he could find no trace of this bone.

In a specimen of *Moxostoma aureolum*, I find the temporal groove directed postero-mesially, practically as shown in Sagemehl's figures of *Catostomus teres*, but its anterior wall is formed by a tall and thin ridge, instead of by a broad surface, as is apparently shown in Sagemehl's figures of *Catostomus*. The antero-mesial end of the groove is roofed by the postero-lateral portion of the parietal, that bone here widely separating the superficial portions of the epiotic and pterotic. A deep V-shaped incisure, which lies in the axis of the temporal groove, cuts into this roof-forming part of the parietal, the two limbs of the V forming the antero-mesial portions of the anterior and posterior bounding edges of the groove. The remainder of the anterior bounding edge of the groove is formed by a ridge on the pterotic, the corresponding part of the posterior bounding edge being formed, in its mesial portion, by a ridge on the epiotic, and, in its lateral portion, by the dorsal edge of the opisthotic. The epiotic portion of the edge corresponds to the mesial edge of the groove of *Scorpæna*, and to that edge of the deeper posterior portion of the groove of *Scomber*, this portion of the edge of the groove of *Moxostoma* ending abruptly in a perpendicular portion which corresponds to the mesial edge of the posterior opening of the groove of the other two fishes. The opisthotic portion of the edge begins at the base of this perpendicular portion, and corresponds to the floor and the lateral edge of the posterior opening of the groove of *Scorpæna* and *Scomber*. There is accordingly, in this edge of the groove of *Moxostoma*, a large angular incisure, and it opens directly into the dorsal portion of a conical depression on the posterior surface of the cranium, which gives insertion to a portion of the trunk-muscles.

The opisthotic is a relatively large, concave-convex bone, the concave surface presented posteriorly and the convex surface antero-laterally, and it is difficult to comprehend how it could have been wanting in Sagemehl's specimens of *Moxostoma succetta*. The posterior portion of the posterior process of the pterotic rests against the antero-lateral surface of the opisthotic, near its dorsal edge, and has there anchylosed with it, but the base of the process does not touch the opisthotic, an opening there being left between the two bones and giving passage to the supratemporal branch of the nervus vagus. The opisthotic of this fish thus corresponds to that part of the opisthotic of *Scomber* and *Scorpæna* that lies mesial to the lateral occipital ridge, this accounting for the fact that it lies against the mesial, instead of the lateral, surface of the posterior process of the pterotic. The posterior process of the pterotic forms the floor of the lateral opening of the temporal groove, this floor of the opening lying at a considerably higher level than the floor of the remainder of the groove. The dorsal portion of the supraclavicula lies in a somewhat vertical position, and its internal edge has a slight antero-posterior sliding motion on the posterior portion of the floor of the opening of the temporal groove, a curved process on the dorsal edge of the supraclavicula hooking over the edge of the epiotic, from its anterior to its posterior surface, between the summit of the epiotic and a slight process mesial to it; the supraclavicula thus completely closing the angular incisure in the posterior edge of the temporal groove.

The suprascapula of Sagemehl's descriptions lies, as he has stated, along the posterior surface of that part of the epiotic that forms the posterior edge of the temporal groove, and is without pedicel, and neither it nor the supraclavicula come into contact with the opisthotic. The suprascapula has no pedicel, and, furthermore, is not traversed by the main latero-sensory canal. This bone of this fish thus cannot, as will be later further explained, represent the whole of the similarly named bone of *Amia* and most of the Teleostei. The absence of a pedicel to this bone, together with the presence of a large opisthotic, is unusual, for the two are usually associated with each other, a ligament first developing between the suprascapula and the cranium, as above described in *Lepidosteus*, this ligament then undergoing ossification at its suprascapular end, and this ossification later inducing ossification at its point of articulation with the cranium. In *Esox*, where the suprascapula has a well-developed pedicel, the opisthotic is said to be wanting (Starks, '04), but in a single specimen of this fish that I have examined I find it well developed as a large membrane-bone loosely attached to the cranium.

The temporal groove of *Moxostoma* lodges a muscle which, after it issues from the groove, lies posterior to the levator operculi, in contact with it, and to all appearance a part of it, but it is inserted in part on the dorsal end of the supraclavicula and in part in the dermis that forms the dorsal corner of the gill-opening. The distal portion of this muscle is quite certainly innervated by the ramus opercularis facialis, and is hence a derivative of the levator operculi, and it has acquired entrance into the temporal groove by passing upward external to the posterior process of the pterotic. This suggests a secondary rather than a primary arrangement, and leads one to suppose that the groove was primarily developed in relation to an invasion by the trunk-muscles, and that the dorso-mesial portion of the muscle that actually occupies the groove has, possibly, been derived from a portion of the trunk-muscles that was cut off from the parent muscle by the peculiar attachment of the supraclavicula. In favour of this assumption are the facts that this dorso-mesial portion of the muscle seems to be in a somewhat disintegrated condition, that the groove here contains considerable fatty tissue, and that, in certain other fishes (*Amia*, Allis, '97, p. 567), the levator operculi does actually invade a temporal groove already occupied by an anterior extension of the trunk-muscles. Furthermore, the position of the epiotic, somewhat removed from the dorso-postero-lateral corner of the cranium, would seem to indicate that the trunk-muscles had, in the ancestors of this fish, occupied the temporal groove. It is, however, to be noted that, even in a 57 mm. specimen of *Catostomus occidentalis*, which I have examined in serial sections, this muscle has no slightest connection with the trunk muscles.

In *Ameiurus*, McMurrich ('84) describes a cavity enclosed between the pterotic, epiotic, and supraoccipital bones, which he says is, in all probability, a rudiment of the temporal fossa of Sagemehl's descriptions of *Amia*. It is said to contain only fatty tissue, and its opening is said to be almost closed by the supraclavicula. The supraclavicula is said to be "a T-shaped bone, of which the upper portion of the transverse limb articulates with the pterotic and epiotic, and almost occludes the opening of the temporal fossa, while the extremity of the vertical limb articulates with the side of the basioccipital." I have shown, in an earlier work (Allis, '04), that the superficial portion of the transverse limb of this bone is traversed by the main latero-sensory canal, and this led me to call the entire bone the suprascapula. The bone has a mesial limb which was said by me to lie in a vertical plane, its anterior surface resting against the hind edge of the dorsal surface of the cranium, and its ventral edge partly upon the epiotic and partly upon a bone which I considered to be a greatly reduced parietal. The relations, to the cranium, of this mesial limb of this bone of *Ameiurus* thus strongly resemble those of the dorsal end of the supraclavicula of *Moxostoma*, provided that the parietal bone of my descriptions of *Ameiurus* is the so-called suprascapula of *Moxostoma*, which seems highly probable. It must then be that the suprascapula of *Amia* and most of the Teleostei is composed of two components, one of latero-sensory and the other of membrane origin, that these two components are found separated from each other in both *Moxostoma* and *Ameiurus*, and that the latero-sensory component persists as an independent, superficial, dermal ossicle in *Moxostoma*, but has fused with the supraclavicula in *Ameiurus*. The temporal fossa of *Ameiurus* would then be strictly similar to that of *Moxostoma*, but greatly reduced in size, the muscle, or muscles, that primarily invaded and occupied it having been entirely excluded from it by the progressive utilization of the fossa as an articular cavity for the dorsal end of the supraclavicula. In *Macrones*, the temporal fossa is apparently much more strongly developed than in *Ameiurus*, and Bridge and Haddon ('93) definitely say that it serves as an articular cavity for what they call the ascending process of the post-temporal, but which is, in fact, the dorsal end of the supraclavicula. In *Silurus glanis*, I find conditions strictly similar to those in *Macrones*, and they are indicated in Jaquet's ('98) figures of this fish.

In *Ameiurus* the adductor mandibulæ has invaded the dorsal surface of the cranium by passing upward over the ridge of the lateral semicircular canal and external to the main latero-sensory canal, and it occupies what corresponds to the region of the primitive supraotic depression. In *Silurus* it is the trunk-muscles that invade this region of the dorsal surface of the cranium, but they here pass mesial to the summit of the epiotic bone, thus traversing what corresponds to the mesial, instead of the lateral, one of the two branch depressions at the hind end of the supraotic depression of *Lepidosteus*.

In *Conger conger* there is a very definite supraotic depression, but there is no vestige, even, of a branch depression leading from it, either laterally or posteriorly, between the pterotic and epiotic. The adductor mandibulæ has here invaded the dorsal surface of the cranium, as in *Ameiurus*, by passing upward over the ridge of the lateral semicircular canal and external to the main latero-sensory canal.

In embryos of all of these teleosts there undoubtedly is a supraotic depression similar to that in embryos of *Lepidosteus*, for both Parker ('73) and Gaupp ('05) show such a depression in embryos of *Salmo*. In Parker's fifth stage of *Salmo* (fry of the second week after hatching) there is as yet no noticeable postorbital process, but there is said to be, on the ventral surface of the ridge of the lateral semicircular canal, a slight ridge which "sets bounds externally to the facet for the extended head of the hyomandibular." The conditions in embryos of the Holostei and Teleostei are thus probably strictly similar, but in the Holostei the pterotic portion of the spheno-pterotic ridge persists as cartilage, while in the adults of the Teleostei above considered the entire ridge is of bone, and this bone has so-called primary relations to the chondrocranium. The ridge of the adult teleost thus overlies the ridge of embryos, and is a ridge of the dermocranium instead of the chondrocranium, excepting, possibly, in fishes such as *Moxostoma*, where the latero-sensory ossicles have not, in this region, fused with the underlying bones. There is, in all of these fishes in which there is an opisthotic bone, a more or less developed opisthotic ridge, which runs antero-ventrally from the summit of the suprascapular process of the opisthotic towards the facialis opening of the trigemino-facialis chamber, and it must, primarily, have ended, anteriorly, in the dorsal edge of that opening. The vena jugularis, after it issues from the facialis opening of the trigemino-facialis chamber, runs posteriorly ventral to the opisthotic ridge, thus lying considerably ventral to the spheno-pterotic ridge and in no relation whatever to it. The subtemporal fossa, when present, lies dorsal to the opisthotic ridge, and the adductor and levator operculi, and the levatores arcuum branchialium, have their origins either on, or dorsal to the latter ridge, the surface of origin lying, in the Teleostei, in part on the secondarily developed posterior process of the pterotic.

In the Selachii the conditions are somewhat different from those above described, and this is unquestionably related to the fact that the hyomandibula of these fishes has been developed from the epihyal, instead of from the branchial-ray bars of the hyal arch. Apparently related to this, the lateral semicircular canal lies lateral to the auditory vesicle (sacculus ?) and in a nearly horizontal position.

In *Acanthias*, both Gegenbaur ('72) and Wells ('17) show, on the dorsal surface of the chondrocranium, ridges which are said to mark the positions of the anterior and posterior semicircular canals. Between these two ridges, mesially, and the dorso-lateral edge of the chondrocranium laterally, there is a slight depression which, according to Wells's figures, forms the surface of insertion of a portion of the trunk-muscles, but I find it giving insertion to those muscles in its posterior portion only, its anterior portion being occupied by a tough ligamentous structure which has the appearence of being a tendinous anterior extension of the trunk-muscles, but is not actually a tendon of those muscles. This depression is thus a supraotic depression similar to that in the Holostei and Teleostei, but it corresponds to the mesial portion, only, of the depression of the latter fishes, for the dorso-lateral edge of this portion of the chondrocranium lies, in *Acanthias*, considerably dorsal to the ridge of the lateral semicircular canal, separated from it by a large concave surface which lies on the lateral surface of the chondrocranium and gives insertion to the levator maxillæ superioris (Csd_1) and the muscle Csd_2. The lateral edge of the supraotic depression forms, as above stated, the dorso-lateral edge of the chondrocranium, it begins anteriorly at the summit of the postorbital process, and the main infraorbital latero-sensory canal lies superficial and slightly mesial to it. This edge of the depression, which is called by Wells the supraotic crest, is therefore certainly the homologue of the spheno-pterotic ridge of the Holostei and Teleostei, notwithstanding that it does not lie along the ridge of the lateral semicircular canal.

The hyomandibula is said by Wells to articulate with the "postero-lateral surface of the cranium, in the region of the horizontal semicircular canal," and she shows it, in her figures, lying much farther posteriorly than Gegenbaur shows it, and than I find it in two specimens that I have examined. She shows it apparently directed dorso-posteriorly, while I find it, when the palato-quadrate is put in the position shown in her figure 5, directed dorso-anteriorly, with its dorsal end partly hidden internal to the palato-quadrate. Its articular facet lies ventral to the ridge of the lateral semicircular canal, and external to the ventral portion of the auditory vesicle (sacculus?), a slight ridge marking its dorsal edge. The vena jugularis lies between this latter ridge and the summit of the ridge of the lateral semicircular canal, and traverses a short canal through the postorbital process. The posterior opening of this canal lies immediately ventral to the anterior end of the ridge of the lateral semicircular canal, and is apparently not shown in Wells's figures. The ridge of the lateral semicircular canal thus forms the dorsal edge of the groove that lodges the vena jugularis, and in this corresponds, as will be seen later, to the opisthotic ridge of *Polypterus*. The levator maxillæ superioris has its insertion, in my specimen, on that part of the palato-quadrate that lies posterior to the so-called palatine process of Wells's figure, instead of anterior to that process, as shown by her, and no part of the adductor mandibulæ has its insertion near the anterior end of the palato-quadrate.

In *Heptanchus*, the conditions, as shown in Gegenbaur's ('72) figures, are similar to those in *Acanthias*, but the anterior portion of the spheno-pterotic ridge has undergone special development to form an articular facet for the dorsal edge of the palato-quadrate.

In a prepared skull of a 10 cm. embryo of *Mustelus*, I find the dorso-lateral edge of the chondrocranium formed by the ridge of the lateral semicircular canal, and between this ridge and the ridges of the anterior and posterior semicircular canals there is a marked supraotic depression. The postorbital process is but slightly developed, and is hardly recognizable. In adult specimens of this fish the postorbital process is strongly developed, as shown in Gegenbaur's ('72) figures of this fish and of the closely related *Galeus*, and a spheno-pterotic ridge runs postero-mesially from the outer end of this process to the summit of the ridge of the lateral semicircular canal, and there vanishes; the spheno-pterotic ridge of this fish thus forming the dorso-lateral edge of the larger anterior portion of the otic portion of the chondrocranium, but the posterior portion of that edge being formed by the ridge of the lateral semicircular canal. The hyomandibula articulates with the lateral surface of that part of the otic capsule that lodges the ventral portion of the auditory vesicle, and there is a sharp ridge forming the dorsal edge of its articular facet. The vena jugularis lies dorsal to this latter ridge, in a groove which has a slight ridge along its dorsal edge. Dorsal to this groove, between it and the dorso-lateral edge of the chondrocranium, the levator maxillæ superioris and the muscle Csd_2 have their insertions. The trunk-muscles have invaded the supraotic depression, and occupy the whole of it. The main infraorbital latero-sensory canal lies superficial to the lateral portion of the supraotic depression.

In the Selachii, there is thus, as in the Holostei and Teleostei, a spheno-pterotic ridge which is developed wholly independently of the ridge of the lateral semicircular canal, but may lie, in part, along that ridge. The sphenotic portion of the ridge is developed in relation to the postorbital process, and in *Heptanchus* gives articulation to the otic process of the quadrate. No portion of the ridge has any relations whatever to the articular facet for the hyomandibula.

In embryos of *Polypterus*, Budgett ('02) shows a supraotic depression similar to that in *Lepidosteus*, and, as in that fish, it does not become a functional temporal fossa. The lateral edge of the depression is formed by the pronounced ridge of the lateral semicircular canal, this ridge being called by Budgett the pterotic ridge. The anterior portion of this ridge is said to give off the "sphenotic wing," which forms a pronounced postorbital process. In a 75 mm. specimen of this fish I find the dorso-lateral edge of the postorbital process forming a pronounced sphenotic ridge, which vanishes posteriorly along the dorso-lateral edge of the anterior portion of the ridge of the lateral semicircular canal. Posterior to this ridge, another ridge begins along the same edge of the ridge of the lateral semicircular canal, and there forms the dorsal edge of the articular facet for the hyomandibula, this ridge evidently being developed in definite relation to the facet. Posterior to the facet, this ridge vanishes, and the dorso-lateral edge of the chondrocranium is there formed, at first by the ridge of the lateral semicircular canal, and then by a ridge which lies at first along the lateral surface of the ridge of that canal, but, farther posteriorly, rises gradually to the level of the dorsal edge of that ridge. Ventral to this ridge, a low and rounded ridge marks the position of the lateral semicircular canal, and the vena jugularis lies immediately ventral to it, between it and the swelling of the bulla acustica.

In the adult *Polypterus* there is a strongly developed opisthotic ridge, which begins, anteriorly, at the dorsal edge of the facialis opening of the trigemino-facialis chamber and runs posteriorly to the summit of the process-like, dorso-postero-lateral corner of the chondrocranium. It forms a projecting roof to the groove that lodges the vena jugularis, and the articular facet for the hyomandibula lies immediately dorsal to it and partly on its dorsal surface, the ridge thus, in a measure, forming the ventral edge of that facet. The dorsal edge of the latter facet is a sharp and strongly defined ridge, the anterior portion of which lies on the chondrocranium and the posterior portion along the lateral edge of the dermal parieto-pterotic. When this latter bone is removed, that part of the ridge that lies on the chondrocranium is seen to vanish posteriorly along the dorsal surface of the opisthotic process, the pterotic and opisthotic ridges of the chondrocranium thus being there confluent. The sphenotic portion of the spheno-pterotic ridge is not well defined in the region of the postorbital process, but, anterior to that process, an anterior continuation of it is formed by the lateral edge of that long, anteriorly projecting, process-like portion of the postfronto-sphenotic that is shown in Traquair's ('71) figures of this fish. Between this process-like portion of the postfronto-sphenotic and the sphenoid bone, there is a large supraorbital fontanelle, roofed by the frontal, and the musculus temporalis has its origin on the ventral surface of this roofing portion of the frontal bone. The postorbital bone is attached both to the anterior end of the process-like portion of the postfronto-sphenotic and to an adjacent angle on the lateral edge of the frontal, the posterior margin of the orbit thus lying considerably anterior to the postorbital process of the chondrocranium.

The conditions in a few of the higher vertebrates may now be considered, the supraotic depression, which is found more or less developed in all of them, being left out of further consideration.

In a 29 mm. embryo of *Rana fusca*, Gaupp ('93) describes a so-called processus oticus quadrati which is said to be a short rod of cartilage which extends from the most postero-lateral portion of the quadrate to the most antero-laterally projecting portion of the ridge of the lateral semicircular canal. It is said to be, as its name implies, a process of the quadrate, but it has exactly the position of that posterior part of the sphenotic portion of the spheno-pterotic ridge of Veit's 20½ mm. embryo of *Lepidosteus* that lies lateral to the recessus dorsalis spiracularis. In an older specimen of *Rana*, at a stage which represents the end of the period of metamorphosis, a strong and overhanging ridge has developed along the outer surface of the ridge of the lateral semicircular canal, at the point where the processus oticus quadrati had previously fused with the latter ridge. Gaupp calls this overhanging ridge the crista parotica, and the so-called processus oticus quadrati forms a connection between the outer edge of this crista and the postero-lateral corner of the quadrate. In a still older specimen, a young frog immediately after the metamorphosis, the crista parotica is said to be much more strongly developed, and to form a sort of roof to the tympanic cavity (Paukenhöhle); and, because of this, Parker is said to have called this ridge the tegmen tympani. The processus oticus quadrati is said to have now been absorbed by the crista parotica, and it is the body itself of the quadrate that rests against, and is fused with, the so-formed crista parotica. The vena jugularis lies directly beneath this crista, and the nervus facialis directly beneath that vein. The pars ascendens of the quadrate, called by Gaupp the pars metapterygoidens, lies in a nearly vertical position, and its dorsal end lies opposite that part of the cranial wall from which, in fishes, the postorbital process projects laterally or ventro-laterally. The columella and the annulus tympanicus are both connected, by cartilage, with the crista parotica, the columella lying anterior to the ramus hyomandibularis facialis and hence corresponding to the anterior articular head of the teleostean hyomandibula. The posterior portion of the hammer-shaped paraquadratum of Gaupp's ('05) later descriptions, the ossa tympanica of one of his earlier works ('96), lies upon the outer surface of the crista parotica, the anterior portion of this limb projecting anteriorly as the processus zygomaticus; this bone thus strongly recalling but probably not representing the dermal, postfrontal portion of the postfronto-sphenotic of *Polypterus*. Parker ('71) calls this bone the temporo-mastoid, and says that it "would seem to combine the supratemporal and preopercular of the Triton, or of the Siluroid or Ganoid Fishes."

In embryos of *Lacerta*, the crista parotica is said by Gaupp ('00) to be, as in *Rana*, a ridge which projects ventro-laterally from the most projecting portion of the ridge of the lateral semicircular canal, but this projecting portion of the latter ridge lies in its posterior portion, instead of, as in *Rana*, near its anterior end. On the crista parotica there is said (*l. c.* p. 451) to be an independent, anteriorly directed process, the summit of which lies internal to, and closely against, the hind edge of the dorsal end of the quadrate. Gaupp calls this little process the processus paroticus, and says that a thin strand of tissue, composed of closely agglomerated cells, extends forward from its summit and is continuous with a sharp ridge which lies dorsal to the columella. This latter ridge is shown, in the figures given, lying dorsal also to the foramen faciale, in a position that suggests a remnant, or primordium, of the lateral wall of the pars ganglionaris of the trigemino-facialis chamber of fishes, which wall is, otherwise, wanting in this reptile. The thin strand of closely agglomerated cells above referred to, then possibly represents a part of the sphenotic ridge of fishes, and hence also the so-called processus oticus *quadrati of Gaupp's descriptions of Rana.*

The processus paroticus of *Lacerta* is said by Gaupp (*l. c.* p. 463) to have been primarily independent of the crista parotica and continuous with the columella auris, and only in later stages of development to have become independent of the columella and completely fused with the crista parotica. In embryos of *Crocodilus biporcatus*, the processus paroticus of Gaupp's descriptions is called by Shiino ('14, p. 325) the processus dorsalis of the columella, and it is said by him to never become either detached from the columella or fused either with the crista parotica or the quadrate. In *Crocodilus porosus* this process is said to fuse with the quadrate. The quadrate of *Lacerta* does not fuse with the cranial wall. In *Crocodilus biporcatus* it fuses with the otic capsule at a point which corresponds exactly to the point of origin of the postorbital process of fishes, and it is separated from the anterior end of the crista parotica by a considerable interval. The process formed, in *Lacerta*, by the fusion of the processus paroticus with the crista parotica is said by Gaupp (*l. c.* p. 519) to quite certainly be the homologue of the processus styloideus of Mammals; and the vena jugularis and the nervus facialis both run posteriorly beneath this process and the crista.

In embryos of the rabbit, the crista parotica is said by Voit ('09, pp. 449-451) to be a tall and plate-like ridge which projects ventro-anteriorly from the anterior edge of the ridge of the lateral semicircular canal, the anterior edge of the latter ridge of the rabbit corresponding to the ventral edge of the ridge of fishes. Posterior to the crista parotica there is said to be a depression (Grube), the lower part of which is particularly deep and forms a fossa subarcuata lateralis which sinks into the massa angularis. This fossa must accordingly lie between the crista and the ridge of the lateral semicircular canal, for otherwise it could not sink into the massa angularis. The figures given favour this interpretation of it, and it would seem to be confirmed by the conditions in embryos of *Echidna*, where Gaupp ('08) shows, in figures of transverse sections, the crista parotica arising from the lateral wall of the otic capsule considerably ventral to the ridge of the lateral semicircular canal and separated from it by a slight depression. The upper (anterior) end of the crista of the rabbit is said by Voit to "encounter" the lower (posterior) end of the tegmen tympani, and then to be continued onward in a slight ridge, the crista facialis, which ends anteriorly in the dorsal edge of the foramen by which the nervus facialis issues from the cavum supracochleare. The latter foramen is called the foramen faciale externum s. secundarium, and its external opening is called the apertura tympanica canalis facialis. The dorsal end of the hyal cartilage (Reichert's cartilage) fuses with the internal surface of the anterior (morphologically ventral) edge of the crista parotica to form the processus styloideus. Posterior to the latter process, the processus mastoideus arises from the outer edge of the crista parotica. Beneath the crista facialis there is a groove, the sulcus facialis, which lodges the nervus facialis after it issues from the apertura tympanica canalis facialis, and this sulcus is continued posteriorly in the angle between the crista parotica and the lateral wall of the otic capsule. The crista parotica of this mammal thus has the general position and relations of the opisthotic ridge of fishes, rather than those of any part of the spheno-pterotic ridge, and its anterior prolongation, the crista facialis, certainly does not represent any part of the latter ridge.

The tegmen tympani of the rabbit is said by Voit (*l. c.* p. 448) to arise from the lateral surface of the but slightly developed prominentia utriculo-ampullaris superior, thus being related to the anterior (superior), instead of the lateral semicircular canal. It is said to project laterally and upward as an arched umbrella-shaped roof ("leicht gewölbtes schirmförmiges Dach), and also to extend forward a certain distance, there arching over the nervus facialis and, beyond that nerve, fusing with the pars cochlearis of the otic capsule, along the lateral edge of the planum supracochleare; thus forming the lateral wall of the cavum supracochleare, the ventral portion of which is perforated by the foramen faciale externum s. secundarium. That part of the tegmen that lies anterior to this foramen is said (*l. c.* p. 533) to correspond to the freely projecting processus perioticus superior Gradenigos of certain other mammals, and to be continued anteriorly a certain distance by procartilaginous tissue which later chondrifies. The commissura capsulo-parietalis fuses with the dorsal surface of the umbrella-shaped tegmen tympani, and it is that part of the tegmen that lies ventro-mesial to the line of this fusion that forms the lateral wall of the cavum supracochleare, the part that lies lateral to the line of fusion forming a tall ridge which projects ventro-laterally and extends posteriorly slightly beyond the anterior end of the crista parotica, where it curves ventrally to meet the basal portion of that crista. This ridge, alone, is frequently referred to in the text as the tegmen tympani, and it is it alone that is so designated, in the figures, by the index letters. The fossa that lies between this ridge and the crista facialis is called the fovea epitympanica, and its posterior portion is said to be deepened to form the fossa incudis, this latter fossa lying, as shown in the figures, on the external surface of the otic capsule, while the anterior portion of the fovea epitympanica lies upon the external surface of the lateral wall of the cavum supracochleare. The tegmen tympani is said to be a direct anterior prolongation of the crista parotica, but one is in doubt as to whether this applies to that part of the tegmen that forms the mesial wall of the fossa epitympanica or the part that forms its roof. The crista facialis is also said, as above explained, to be a direct anterior prolongation of the crista parotica, and yet this crista is simply a ridge on the external surface of that part of the tegmen that forms the mesial wall of the fovea epitympanica.

Van Kampen ('05), in an earlier work, gives a somewhat different description of the tegmen tympani of Mammals in general. According to him (*l. c.* p. 344), Reichert's cartilage fuses with a cartilaginous ridge which arises from the outer surface of the ridge of the lateral semicircular canal. Anterior to the point of this fusion, the ridge separates into two parts, one of which is called by Van Kampen the crista facialis, and corresponds to the similarly named crista of Voit's descriptions of the rabbit. The other part of the ridge is said to lie at a higher level than the crista facialis, and the two ridges enclose between them a part of the wall of the pars vestibularis of the otic capsule which Van Kampen calls the mesial wall of the recessus epitympanicus, this recess, as thus described, thus lying wholly on the external surface of the otic capsule, and not partly on the lateral wall of the cavum supracochleare. The upper one of the two enclosing ridges forms the roof of the recessus epitympanicus, and corresponds exactly to the roof of that recess of Voit's descriptions of the rabbit, and it is said that it is this roof alone that forms, in human anatomy, the tegmen tympani. The tegmen tympani of human embryos, as thus defined, is thus a ridge which forms a part of the external, instead of the internal, wall of the recessus epitympanicus, and hence is in no way comparable to the tegmen tympani of the adult Man, where it is a thin plate of bone which lies between the tympanic and cerebral cavities and separates them one from the other. In Mammals other than Man, the recessus epitympanicus is said to be less tall, and as, in consequence of this, the roof of the recess and the crista facialis are not distinctly separated from each other, they are both considered to be included in the tegmen; the tegmen of these Mammals, as thus defined, thus corresponding to the tegmen of the rabbit as described by Voit, and forming the mesial wall and part of the external wall of the recessus epitympanicus. The crista facialis alone is said by Van Kampen to probably be the homologue of the crista parotica of *Lacerta*, and Gaupp ('08, p. 687) accepts this as correct. Gaupp also further says that the tegmen tympani is a new formation which first appears in Mammals, but that it is wanting in *Echidna*; and yet he shows, in one of his figures (*l. c.* fig. 44, p. 628), a portion of the crista parotica which has, to the incus, exactly the relations of that part of the tegmen tympani of both Voit's and Van Kampen's descriptions that forms the roof of the recessus epitypanicus. Van Kampen, in the figure of a new-born *Ovis*, shows the tegmen tympani as a right-angled ridge the anterior portion of which forms the roof of the fossa muscularis major and ends in the transverse plane of the hiatus facialis. The anterior portion of the tegmen is said by Van Kampen to be very variable, and to often be wholly wanting, and in Man it is said to arise, not as a ridge, but as an anteriorly projecting process, the processus perioticus superior Gradenigos. The process lies, as shown in the figure given (*l. c.* fig. 3, p. 342), definitely anterior to the recessus epitympanicus, and anterior also to the column of cartilage that forms the anterior boundary of the foramen faciale externum s. secundarium; and the ossification of this process and the layer of connective tissue that separates it from the pars cochlearis of the otic capsule is said to form the tegmen tympani of the adult. The mesial wall and the roof of the recessus epitympanicus of embryos thus, neither of them, enters into the tegmen tympani of the adult.

There is thus some want of accord and precision in the descriptions of the tegmen tympani by these authors, and this has in a measure been perpetuated in later descriptions. Fawcett, for example, says ('17, pp. 319–321) that the tegmen tympani of

Microtus is a curved shell-like cartilage which projects forward from the base of the triangular lateral surface of the otic capsule, "over the incus and malleus cartilages"; that the recessus epitympanicus has been formed by the hollowing out of the under surface and root of the anterior prolongation of the tegmen tympani; and that the posterior portion of the latter recess has been deepened to form a fossa incudis which lies on the "upper aspect" of the crista parotica. The tegmen tympani of this mammal, as thus described, would thus seem to be nothing more than the ridge that forms, in Voit's descriptions of the rabbit, the roof of the fovea epitympanica; and it would seem as if it could not be an anterior prolongation of the crista parotica, for its posterior portion, which forms the dorsal boundary of the fossa incudis, must lie either on the external surface of the crista parotica, or on the external surface of the otic capsule immediately dorsal to that crista. In *Erinaceus* the tegmen tympani, as described by Fawcett ('18), also forms the roof of the recessus epitympanicus, but it would here seem to be a direct anterior prolongation of the crista parotica. Terry ('17) does not consider that part of the ridge of these descriptions that forms the roof of the fossa incudis to be a part of the tegmen tympani, for he says (*l. c.* p. 300) that the tegmen tympani is not present in a 23·1 mm. embryo of the cat, and yet he shows, in his figure 3, a well-developed fossa incudis which is bounded dorsally by a strongly marked but not projecting ridge which is evidently the homologue of the posterior portion of the roof of the fovea epitympanica of Voit's, Van Kampen's, and Fawcett's descriptions. The mesial wall of the fossa incudis is apparently, and correctly, not considered by either Fawcett or Terry to form part of the tegmen tympani.

Comparing these conditions in Mammals with those in Fishes, it is evident that that part of the tegmen tympani of Voit's descriptions of the rabbit that forms the lateral wall of the cavum supracochleare, together with its anterior procartilaginous prolongation, is the post-trigeminus portion of the lateral wall of the pars ganglionaris of the trigemino-facialis chamber of Fishes. That so-called part of the tegmen that forms the roof of the fovea epitympanica must then be the sphenotic portion of the spheno-pterotic ridge of Fishes. The incus, which lies immediately ventral to this roof, then has the relations to it that it normally should, if, as I have lately endeavoured to show (Allis, in press), it is the homologue of the otic process of the quadrate of *Heptanchus*, of the corresponding part of the quadrate of the Amphibia and Reptilia, and of the lateral wall of the pars jugularis of the trigemino-facialis chamber of Fishes. The crista facialis certainly corresponds to the anterior portion of the opisthotic ridge of *Polypterus*, and the crista parotica is usually shown as a direct posterior continuation of this crista, and not of the roof of the fovea epitympanica. The crista parotica would thus seem to correspond to the posterior portion of the opisthotic ridge of Fishes, rather than to the pterotic portion of the spheno-pterotic ridge. The relations of the processus zygomaticus of Man to the region of the roof of the fovea epitympanica—that is to the sphenotic ridge—would therefore seem to indicate that it has been derived from, or at least contains, the long, anteriorly projecting process of the postfronto-sphenotic of *Polypterus*; and the temporal fossa of Man would arise if that part of the frontal of *Polypterus* that roofs the supraorbital fontanelle were to be suppressed by the wearing action of the musculus temporalis. That angle of the frontal of *Polypterus* that gives articulation to the post-orbital bone would then correspond to the external angular process of the frontal of Man, and the postorbital bone would correspond to the malar bone of Man; this all being in accord with my conclusion (Allis, '00) that the maxillary bone of *Polypterus* is the homologue of the maxillary part of the superior maxillary bone of Man, and that neither of these bones is the homologue of the teleostean maxillary.

Palais de Carnolès, Menton, France,
April 30, 1919.

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16. A List of the Snakes of West Africa, from Mauritania to the French Congo. By G. A. Boulenger, F.R.S., F.Z.S.

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(Text-figures 1 & 2.)

After an interruption of four years, due to the restrictions imposed on the Society's publications, I am now able to continue the series of lists of African Snakes, accompanied by artificial keys and arranged according to districts, with the object of facilitating identifications*.

The present instalment deals with the western parts of Africa, from Mauritania to the French Congo inclusively. This division is as artificial as the keys, for we know a great many Snakes, until lately believed to be characteristic of West Africa, to extend across the great forest region as far as Uganda and the north-west of Lake Tanganyika. But it is convenient for practical purposes, especially if this list be used in conjunction with that dealing with the Belgian Congo, to which, however, many additions have been made since its publication†. Our knowledge of the Snakes of the interior of Africa is still so imperfect that attempts at mapping out the distribution must be regarded as very provisional.

The figures, in lieu of a glossary, which have already appeared in the 'Proceedings,' are here reproduced (text-figs. 1 & 2).

Synopsis of the Families.

I. Worm-like, with small inferior mouth, eyes hidden or visible under the head shields, and body covered with uniform imbricate scales above and beneath.

Ocular shield not bordering the mouth; tail not or but little longer than broad; 18 scales or more round middle of body ...	Typhlopidæ.
Ocular shield bordering the mouth; 14 scales round middle of body	Glauconiidæ.

II. Mouth large, eyes distinct, exposed; body with enlarged shields beneath.

Ventral shields much narrower than the body; supraocular, if distinct, broken up into two or more shields	Boidæ.
Ventral shields at least nearly as broad as the body; supraocular single; poison-fangs, if below the eye, preceded by smaller teeth	Colubridæ.
Ventral shields nearly as broad as the body; large poison-fangs in a very large sheath below the eye	Viperidæ.

Family Typhlopidæ.

A single genus.

1. Typhlops.

Schneid. Hist. Amph. ii. p. 339; Bouleng. Cat. Sn. i. p. 7

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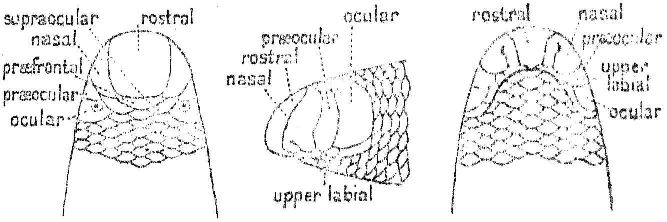
* P. Z. S. 1915, pp. 193, 369, 611, 641.

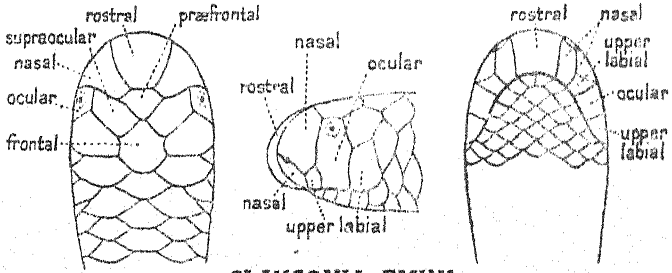
† *Cf.* Boulenger, Ann. Zool. Afr. vii. 1919, p. 1.

Text-figure 1.

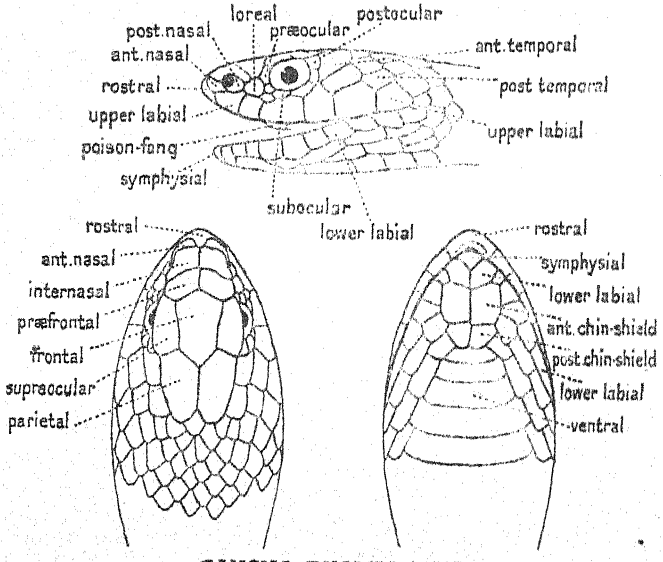
(From P. Z. S. 1915, p. 612.)



TYPHLOPS PUNCTATUS.



GLAUCONIA EMINI.

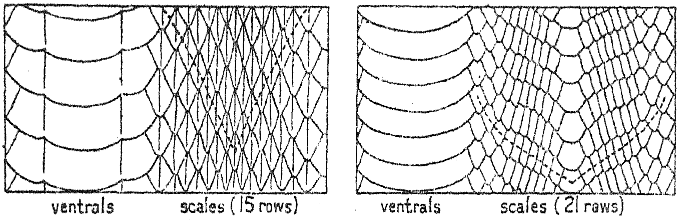


CAUSUS RHOMBEATUS.

J. GREEN DEL.

Text-figure 2.

(From P. Z. S. 1915, p. 613.)

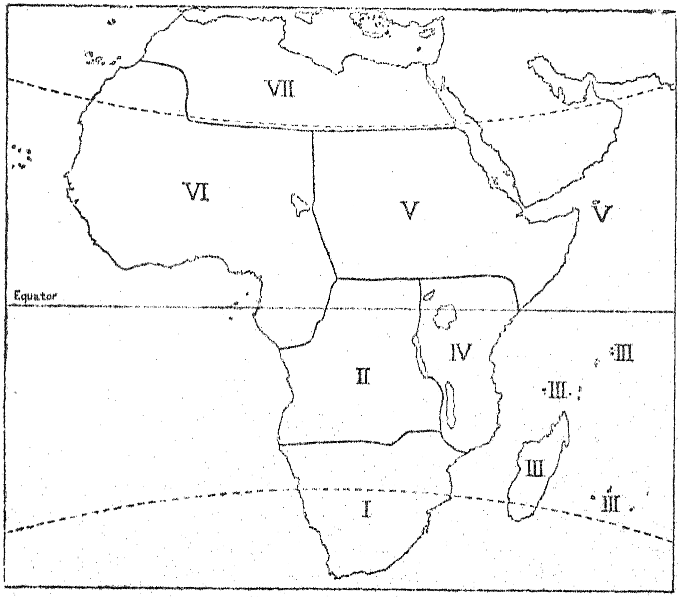


A. B.

Scaling of thickest part of body.

A. *Gastropyxis smaragdina*, with keeled scales and bicarinate ventral shields.
B. *Dipsadomorphus blandingii*, with oblique scales and enlarged vertebrals.

The present list deals with Division VI. of the following map:—



Division of Africa into seven districts.

Synopsis of the Species.

I. No subocular; ocular in contact with two or three upper labials.

A. Rostral not more than one-third width of head; nasal completely divided into two; diameter of body 35 to 50 times in total length.

20 scales round middle of body; eyes distinct; anterior part of nasal extending to upper surface of head …… *T. braminus.*
18 scales round middle of body; eyes hidden …… *T. caecatus.*
22 scales round middle of body; eyes just distinguishable …… *T. leucostictus.*

B. Rostral at least half width of head.

1. Nasal completely divided into two; præocular much narrower than the ocular; eyes distinct.

18 or 20 scales round middle of body, the diameter of which is 36 to 49 times in total length …… *T. elegans.*
24 scales round middle of body, the diameter of which is 66 times in total length …… *T. decorosus.*

2. Nasal incompletely divided; snout (seen from above) rounded.

a. Eyes hidden.

28 scales round middle of body, the diameter of which is 39 to 40 times in total length; præocular much narrower than ocular …… *T. batesii.*
28 scales round middle of body, the diameter of which is 19 times in total length; præocular much narrower than ocular …… *T. hallowelli.*
24 scales round middle of body, the diameter of which is 53 times in total length; præocular nearly as broad as ocular. *T. buchholzi.*

b. Eyes distinguishable; 24 to 30 scales round middle of body.

Diameter of body 41 to 45 times in total length; præocular a little narrower than ocular …… *T. steinhausi.*
Diameter of body 21 to 32 times in total length; præocular much narrower than ocular …… *T. punctatus.*

3. Nasal completely divided; præocular as large as ocular; snout (seen from above) pointed; eyes hidden; tail without terminal spine.

Snout obtusely pointed; 22 scales round middle of body, the diameter of which is 54 times in total length …… *T. crossi.*
Snout obtusely pointed; 20 scales round middle of body, the diameter of which is 51 times in total length …… *T. feæ.*
Snout acutely pointed; 22 scales round middle of body, the diameter of which is 62 to 66 times in total length …… *T. principis.*

II. A subocular separates the ocular from the upper labials; eyes hidden.

18 scales round middle of body, the diameter of which is 35 to 45 times in total length; snout rounded; rostral ⅓ width of head; no caudal spine …… *T. zenkeri.*
20 scales round middle of body, the diameter of which is 70 times in total length; rostral large, with obtuse horizontal edge; a small caudal spine …… *T. rufescens.*
22 scales round middle of body, the diameter of which is 60 to 74 times in total length; rostral large, with sharp horizontal edge; a small caudal spine …… *T. cæcus.*
28 scales round middle of body, the diameter of which is 55 to 70 times in total length; rostral large, with sharp horizontal edge; no caudal spine …… *T. newtonii.*

1. Typhlops braminus Daud.

Bouleng. Cat. Sn. i. p. 16.

Southern Asia; islands of the Indian Ocean; South Africa;

Lagos (*fide* Peters); Mexico.—Distribution probably ascribable to transport by human agency.

2. TYPHLOPS CÆCATUS Jan, Icon. Gén. p. 9, l. 3, pls. iv. & v. fig. 2; Bouleng. t. c. p. 32.

Gold Coast.

3. TYPHLOPS LEUCOSTICTUS Bouleng. Ann. & Mag. N. H. (7) i. 1898, p. 124.

Liberia.

4. TYPHLOPS ELEGANS Peters, Mon. Berl. Ac. 1868, p. 450, pl. ii. fig. 1; Bouleng. Cat. Sn. i. p. 37.

Prince's Id., Gulf of Guinea.

5. TYPHLOPS DECOROSUS Buchh. & Peters, Mon. Berl. Ac. 1875, p. 197.

Cameroon.

6. TYPHLOPS BATESII Bouleng. Ann. & Mag. N. H. (8) viii. 1911, p. 371.

Cameroon.

7. TYPHLOPS HALLOWELLI Jan, Icon. Gén. p. 29, l. 4, pls. iv. & v. fig. 6; Bouleng. Cat. Sn. i. p. 40.

Gold Coast.

8. TYPHLOPS BUCHHOLZI Peters, Sitzb. Ges. Nat. Fr. Berl. 1881, p. 71; Bouleng. Cat. Sn. i. p. 41.

Cameroon.

9. TYPHLOPS STEINHAUSI Werner, Jahrb. Hamb. Wiss. Anst. xxvi. 2, 1909, p. 209.

Cameroon.

10. TYPHLOPS PUNCTATUS Leach.

Bouleng. Cat. Sn. i. p. 42.

Typhlops bocagii Bethencourt Ferreira, Jorn. Sc. Lisb. (2) vii. 1904, p. 114.

Typhlops adolphi Sternf. Mitt. Zool. Mus. Berl. v. 1910, p. 70.

? *Typhlops dubius* Chaban. Bull. Mus. Paris, 1916, p. 364, fig.

Tropical Africa, as far north as the Gambia and Uganda.

11. TYPHLOPS CROSSI Bouleng. Cat. Sn. i. p. 52, pl. iii. fig. 5.

Southern Nigeria.

12. TYPHLOPS FEÆ Bouleng. Ann. Mus. Genova, (3) ii. 1906, p. 209, fig.

San Thomé Id., Gulf of Guinea.

13. TYPHLOPS PRINCIPIS Bouleng. l. c. fig.

Prince's Id., Gulf of Guinea.

14. TYPHLOPS ZENKERI Sternf. Sitzb. Ges. Nat. Fr. Berl. 1908, p. 92.

Typhlops vermis Bouleng. Ann. & Mag. N. H. (8) xiv. 1914, p. 482.

Cameroon.

15. TYPHLOPS RUFESCENS Chaban. Bull. Mus. Paris, 1916, p. 375, fig. (1917).

French Congo.

16. TYPHLOPS CÆCUS.

Onychocephalus cæcus A. Dum. Rev. et Mag. Zool. 1856, p. 462, pl. xxi. fig. 4.

Typhlops cæcus Bouleng. Cat. Sn. i. p. 55.

Sierra Leone to Congo.

17. TYPHLOPS NEWTONII Bocage, Jorn. Sc. Lisb. (2) ii. 1891, p. 61; Bouleng. l. c.

I. das Rolas, Gulf of Guinea.

Family GLAUCONIIDÆ.

A single genus.

1. GLAUCONIA.

Gray, Cat. Liz. p. 139; Bouleng. Cat. Sn. i. p. 59.

Synopsis of the Species.

I. A single upper labial between the nasal and the ocular.

First upper labial as large as or a little smaller than lower part of nasal; diameter of body 38 to 50 times in total length; tail 5 to 10 times as long as broad .... *G. narirostris.*

First upper labial much smaller than lower part of nasal; diameter of body 55 times in total length; tail about 5 times as long as broad .... *G. boueti.*

First upper labial much smaller than lower part of nasal; diameter of body 57 times in total length; tail hardly twice as long as broad .... *G. brevicauda.*

II. Two upper labials between the nasal and the ocular.

Second upper labial twice as large as first but much smaller than the ocular; diameter of body 42 times in total length .... *G. sundevalli.*

Second upper labial very large, nearly as large as the ocular; diameter of body 38 to 43 times in total length .... *G. gestri.*

First and second upper labials small; diameter of body 50 to 65 times in total length .... *G. bicolor.*

First and second upper labials small; diameter of body 78 times in total length .... *G. gruveli.*

1. GLAUCONIA NARIROSTRIS.

Stenostoma narirostre Peters, Mon. Berl. Ac. 1867, p. 708, pl. —. fig. 2.

Glauconia narirostris Bouleng. Cat. Sn. i. p. 65.

Lagos, S. Nigeria, Cameroon.

2. GLAUCONIA BOUETI Chaban. Bull. Mus. Paris 1917, p. 9, figs.

French Soudan.

3. GLAUCONIA BREVICAUDA.

Stenostoma brevicauda Bocage, Jorn. Sc. Lisb. xi. 1887, p. 194.
Glauconia brevicauda Bouleng. t. c. p. 67.

Dahomey and Ashantee.

4. GLAUCONIA SUNDEVALLI.

Stenostoma sundevalli Jan, Arch. Zool. Anat. Phys. i. 1862, p. 191.
Glauconia sundevalli Bouleng. t. c. p. 68.

Togoland.

5. GLAUCONIA GESTRI Bouleng. Ann. Mus. Genova, (3) ii. 1906, p. 210, fig.

Fernando Po and Cameroon.

6. GLAUCONIA BICOLOR.

Stenostoma bicolor Jan, Icon. Gén. p. 40, l. 1, pl. v. fig. 15.
Glauconia bicolor Bouleng. Cat. Sn. i. p. 69.

Gold Coast, Togoland.

7. GLAUCONIA GRUVELI.

Glauconia bicolor gruveli Chaban. Bull. Mus. Paris, 1916, p. 367 (1917)[*].

Dahomey.

Family BOIDÆ.

Three genera :—

Head distinct from neck, with shields above; rostral and anterior upper labials with deep pits; subcaudals paired	*Python.*
Head not distinct from neck, with shields above; tail short, rounded at the end, with single subcaudals	*Calabaria.*
Head not distinct from neck, with small scales above; tail short, pointed, with single subcaudals	*Eryx.*

1. PYTHON.

Daud. Hist. Rept. v. p. 266; Bouleng. Cat. Sn. i. p. 85.

Two species :—

2 upper labials pitted; scales in 81–93 rows; subcaudals 63–77	*P. sebæ.*
4 upper labials pitted; scales in 53–63 rows; subcaudals 30–37	*P. regius.*

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[*] In comparing this snake with *G. bicolor*, M. Chabanaud has, through an oversight, given the length of the tail as the diameter.

1. PYTHON SEBÆ.

Coluber sebæ Gmel. S. N. i. p. 1118.
Python sebæ Bouleng. t. c. p. 86.

Tropical and South Africa.

2. PYTHON REGIUS.

Boa regia Shaw, Zool. iii p. 347, pl. xcvi.
Python regius Bouleng. t. c. p. 88.

Senegambia to Niger, eastwards to the Egyptian Soudan.

2. CALABARIA.

Gray, P. Z. S. 1858, p. 154; Bouleng. Cat. Sn. i. p. 92.

1. CALABARIA REINHARDTI.

Eryx reinhardti Schleg. Bijdr. tot de Dierk. i. p. 2, pl. .
Calabaria reinhardti Bouleng. l. c.

Liberia to Congo, eastwards to the Ituri.

3. ERYX.

Daud. Hist. Rept. vii. p. 251; Bouleng. Cat. Sn. i. p. 122.

1. ERYX MUELLERI.

Gongylophis muelleri Bouleng. Ann. & Mag. N. H. (6) ix. 1892, p. 74.
Eryx muelleri Bouleng. Cat. Sn. i. p. 128, pl. v. fig. 2.

Mauritania, N. Nigeria, Togoland, Egyptian Soudan.

Family COLUBRIDÆ.

Three parallel series:—

No poison-fangs; all the teeth solid	A. Aglypha.
Poison-fangs behind	B. Opisthoglypha.
Poison-fangs in front	C. Proteroglypha.

A. Aglypha.

I. Loreal present.

A. Rostral without angular horizontal edge.

1. Pupil round; a single anterior temporal; not more than two upper labials entering the eye; body not very slender, with not more than 165 ventrals; subcaudals not more than 95; scales not at all oblique; anal usually divided (if entire, scales smooth in 17 rows).

Two internasals	*Tropidonotus.*
A single internasal; nasal semidivided; scales in 25 rows	*Helicops.*
A single internasal; nostril between two nasals; scales in 21 or 23 rows	*Hydræthiops.*

2. Pupil round; a deep concavity on the side of the snout, between the nostril and the eye; anal entire.

Scales keeled, in 23 rows	*Bothrophthalmus.*
Scales smooth, in 17 or 19 rows	*Bothrolycus.*

3. Pupil vertically elliptic; anal entire.

a. Scales smooth, vertebral row not enlarged; subcaudals less than 75.

Scales in 23 to 33 rows .... *Boodon.*
Scales in 17 rows .... *Lycophidium.*

b. Scales of vertebral row enlarged.

Scales smooth, head very distinct from neck .... *Hormonotus.*
Scales keeled, vertebrals bicarinate; anterior teeth not enlarged. *Gonionotophis.*
Scales keeled, vertebrals bicarinate; anterior teeth strongly enlarged .... *Simocephalus.*

4. Pupil round; two superposed anterior temporals, or, if anterior temporal single, 3 upper labials entering the eye, or ventrals more than 165.

a. Scales not oblique, in 31 rows; ventrals 245–254 ... *Zamenis.*

b. Scales more or less oblique, at least on the anterior part of the body, in 13 to 19 rows; body usually very slender (Tree-Snakes).

α. Scales in 13 or 15 rows, of vertebral row not enlarged, laterals as long as dorsals.

* Scales smooth.

Subcaudal shields not keeled .... *Chlorophis.*
Subcaudal shields keeled on each side and with a notch corresponding to the keel, same as on the ventrals .... *Philothamnus.*

** Scales keeled.

Subcaudal shields keeled and notched on each side; a single anterior temporal .... *Gastropyxis.*
Subcaudal shields not keeled; usually two superposed anterior temporals .... *Hapsidophrys.*

β. Scales in 13 or 15 rows, very oblique, laterals shorter than dorsals; eye very large .... *Thrasops.*

γ. Scales in 17 or 19 rows, very oblique; eye very large .... *Rhamnophis.*

c. Scales not oblique, in 15 to 21 rows.

A single anterior temporal; ventrals 171–224; rostral not twice as broad as deep .... *Coronella.*
Two superposed anterior temporals; ventrals 125–168 .... *Grayia.*

B. Rostral very large, with angular horizontal edge.

Eye in contact with labials: scales in 15 rows .... *Prosymna.*
Suboculars separate the eye from the labials; scales in 19 to 25 rows .... *Scaphiophis.*

II. No loreal, nasal in contact with praeocular.

Eye small, with round pupil; no internasals, praefrontal single; scales smooth, in 15 rows .... *Pœcilopholis.*
Eye moderate or rather large, with vertical pupil; a pair of internasals and a pair of praefrontals; scales strongly keeled, in 20 to 27 rows .... *Dasypeltis.*

1. TROPIDONOTUS.

Kuhl, Bull. Sc. Nat. ii. 1824, p. 81; Bouleng. Cat. Sn. iii. p. 192.

Synopsis of the Species.

I. Scales smooth; two upper labials entering the eye.

Scales in 17 rows; ventrals 117–135; anal usually entire; subcaudals 75–95 .... *T. fuliginoides.*
Scales in 15 rows; ventrals 125–143; anal divided; subcaudals 68–77 .... *T. variegatus.*
Scales in 19 rows; ventrals 131–150; anal divided; subcaudals 55–95 .... *T. olivaceus.*

II. Scales strongly keeled, in 21–27 rows; suboculars separate the eye from the labials .... *T. ferox.*

1. TROPIDONOTUS FULIGINOIDES.

Coronella fuliginoides Günth. Cat. Col. Sn. p. 39.
Tropidonotus fuliginoides Bouleng. t. c. p. 217.

Gold Coast to Congo.

2. TROPIDONOTUS VARIEGATUS.

Mizodon variegatus Peters, Mon. Berl. Ac. 1861, p. 358.
Tropidonotus variegatus Bouleng. l. c.

Gold Coast to Cameroon.

3. TROPIDONOTUS OLIVACEUS.

Coronella olivacea Peters, Mon. Berl. Ac. 1854, p. 622.
Tropidonotus olivaceus Bouleng. t. c. p. 227.

Tropical Africa, from the Soudan to Namaqualand and Southern Rhodesia.

4. TROPIDONOTUS FEROX Günth. Ann. & Mag. N. H. (3) xii. 1863, p. 355, pl. vi. fig. F; Bouleng. t. c. p. 241.

Sierra Leone to Calabar.

2. HELICOPS.

Wagler, Syst. Amph. p. 170; Bouleng. Cat. Sn. i. p. 272.

1. HELICOPS GENDRII Bouleng. Ann. & Mag. N. H. (3) v. 1910, p. 512.

French Guinea.

3. HYDRÆTHIOPS.

Günth. Ann. & Mag. N. H. (4) ix. 1872, p. 28; Bouleng. Cat. Sn. i. p. 280.

Two species:—

Scales keeled, in 25 rows; ventrals 143-156; 5th and 6th or 6th and 7th upper labials entering eye..................................	*H. melanogaster.*
Scales smooth, in 21 rows; ventrals 154-165; 4th and 5th upper labials entering eye, 6th and 7th in contact with parietal...	*H. lævis.*

1. HYDRÆTHIOPS MELANOGASTER Günth. Ann. & Mag. N. H. (4) ix. 1872, p. 28, pl. iii. fig. G; Bouleng. t. c. p. 281.

Cameroon to Congo, eastwards to the Ituri.

2. HYDRÆTHIOPS LÆVIS Bouleng. Ann. & Mag. N. H. (7) xiii. 1904, p. 450.

Cameroon.

4. BOTHROPHTHALMUS.

Peters, Mon. Berl. Ac. 1863, p. 287; Bouleng. Cat. Sn. i. p. 324.

1. BOTHROPHTHALMUS LINEATUS.

Elaphis (*Bothrophthalmus*) *lineatus* Peters, l. c.
Bothrophthalmus lineatus Bouleng. l. c.

West and Central Africa, from the Gold Coast and Uganda to the Congo.

5. BOTHROLYCUS.

Günth. P. Z. S. 1874, p. 444; Bouleng. Cat. Sn. i. p. 325.

1. BOTHROLYCUS ATER Günth. l. c. pl. lvii. fig. B; Bouleng. t. c. p. 326.

Pseudoboodon albopunctatus Anderss. Bih. Svensk. Ak. xxvii. iv. no. 5, 1901, p. 6, pl. i. figs. 2–4.

Pseudoboodon brevicaudatus Anderss. t. c. p. 8.

Cameroon, Fernando Po, Ituri.

6. BOODON.

Dum. & Bibr. Mém. Ac. Sc. xxiii. 1853, p. 460; Bouleng. Cat. Sn. i. p. 327.

Synopsis of the Species.

I. Subcaudals in two rows.
  A. Scales in 23 (very rarely 25) rows; belly blackish brown with the middle line yellowish .... *B. virgatus.*
  B. Scales in 25 to 33 rows.
Parietal shields longer than distance between frontal and end of snout; 2 (very rarely 3) upper labials entering the eye .... *B. lineatus.*
Parietal shields longer than distance between frontal and end of snout; 3 upper labials entering the eye.............................. *B. bedriagæ.*
Parietal shields as long as distance between frontal and end of snout. *B. fuliginosus.*
II. Subcaudals single; scales in 25 to 29 rows .... *B. olivaceus.*

1. BOODON VIRGATUS.

Cœlopeltis virgata Hallow. Proc. Ac. Philad. 1854, p. 98.
Boodon virgatus Bouleng. t. c. p. 331.
Gold Coast to Calabar; East Africa (?).

2. BOODON LINEATUS Dum. & Bibr. Erp. Gén. vii. p. 363; Bouleng. t. c. p. 332.

Tropical and South Africa and South Arabia.

3. BOODON BEDRIAGÆ Bouleng. Ann. Mus. Genova, (3) ii. 1906, p. 211.

S. Thomé and Prince's Id., Gulf of Guinea.

4. BOODON FULIGINOSUS.

Lycodon fuliginosus Boie, Isis, 1827, p. 551.
Boodon fuliginosus Bouleng. t. c. p. 334.
Mauritania to N. Nigeria, eastwards to the Egyptian Soudan.

5. BOODON OLIVACEUS.

Holuropholis olivaceus A. Dum. Rev. et Mag. Zool. 1856, p. 466
Boodon olivaceus Bouleng. t. c. p. 335.
West and Central Africa, from Nigeria and Uganda to the Congo.

7. LYCOPHIDIUM.

Dum. & Bibr. Mém. Ac. Sc. xxiii. 1853, p. 462; Bouleng. Cat. Sn. i. p. 336.

Synopsis of the Species.

I. Loreal separated from the eye by the præocular.

A. 8 upper labials.

1. Parietals considerably longer than distance between frontal and end of snout.

2 labials entering the eye, the diameter of which equals its distance from the mouth; ventrals 174-199; subcaudals 32-44 ... *L. laterale.*

3 labials entering the eye, the diameter of which exceeds its distance from the mouth; ventrals 164-208; subcaudals 24-47 ... *L. capense.*

2. Parietals not or but slightly longer than distance between frontal and end of snout.

3 labials entering the eye, the diameter of which is greater than its distance from the mouth; ventrals 164-193; subcaudals 32-53 .... *L. irroratum.*

3 labials entering the eye, the diameter of which is but slightly greater than its distance from the mouth; ventrals 188-219; subcaudals 34-55 .... *L. semicinctum.*

B. 7 upper labials; ventrals 178-198; subcaudals 30-58 ...... *L. fasciatum.*

II. Loreal entering the eye.

7 upper labials; ventrals 185; subcaudals 43 .... *L. werneri.*

8 upper labials; ventrals 225-253; subcaudals 66-74 .... *L. elapoides.*

1. **LYCOPHIDIUM LATERALE** Hallow. Proc. Ac. Philad. 1857, p. 58; Bouleng. t. c. p. 338.

Gold Coast to Congo.

2. **LYCOPHIDIUM IRRORATUM.**

Coluber irroratus Leach, in Bowdich, Miss. Ashant. p. 494.
Lycophidium irroratum Bouleng. t. c. p. 340.

Senegambia to Gold Coast and N. Nigeria.

3. **LYCOPHIDIUM CAPENSE.**

Lycodon capensis A. Smith, S. Afr. Quart. Journ. (1) no. 5, 1831, p. 18.
Lycophidium capense Bouleng. t. c. p. 339.

Tropical and South Africa.

4. **LYCOPHIDIUM SEMICINCTUM** Dum. & Bibr. Erp. Gén. vii. p. 414; Bouleng. t. c. p. 341.

Senegambia, French Guinea, N. Nigeria; East Africa (?).

5. **LYCOPHIDIUM FASCIATUM.**

Alopecion fasciatum Günth. Cat. Col. Sn. p. 196.
Lycophidium fasciatum Bouleng. t. c. p. 342.

Sierra Leone to Gaboon, eastwards to the Congo Forest west of Mt. Ruwenzori.

6. **LYCOPHIDIUM WERNERI** Mocquard, Bull. Mus. Paris, 1902, p. 411.

Gaboon.

7. Lycophidium elapoides Günth. P. Z. S. 1874, p. 444; Bouleng. t. c. p. 343.

Cameroon.

8. Hormonotus.

Hallow. Proc. Ac. Philad. 1857, p. 56; Bouleng. Cat. Sn. i. p. 343.

1. Hormonotus modestus.

Lamprophis modestus Dum. & Bibr. Erp. Gén. vii. p. 429.
Hormonotus modestus Bouleng. l. c.

Gold Coast to Gaboon.

9. Gonionotophis.

Bouleng. Cat. Sn. i. p. 323.

Synopsis of the Species.

I. Scales strongly keeled.

Loreal and præfrontal entering the eye; scales in 21 rows; ventrals 175–185; subcaudals 73–95 .... *G. brussauxi.*

Loreal separated from the eye by a præocular; scales in 19 rows; ventrals 167–173; subcaudals 90–94 .... *G. klingii.*

II. Scales rather feebly keeled, in 15 rows (19 on neck).

Loreal twice as long as deep; ventrals 167–173; subcaudals 67 .... *G. grantii.*

Loreal as long as deep or a little longer; ventrals 210–211; subcaudals 47–54 .... *G. microps.*

1. Gonionotophis brussauxi.

Gonionotus brussauxi Mocquard, Bull. Soc. Philom. (8) i. 1889, p. 146, pl. ii.
Gonionotus vossi Boettg. Zool. Anz. 1892, p. 418.
Gonionotophis brussauxi & *vossi* Bouleng. t. c. p. 323.
? *Simocephalus insignis* Chaban. Bull. Mus. Paris, 1916, p. 369, fig.

Cameroon to Congo.

2. Gonionotophis klingii Matschie, Sitzb. Ges. Nat. Fr. Berl. 1893, p. 172; Bouleng. Cat. Sn. iii. p. 614.

Togoland.

3. Gonionotophis grantii.

Simocephalus grantii Günth. Ann. & Mag. N. H. (3) xii. 1863, p. 361.
Gonionotophis grantii Bouleng. Cat. Sn. i. p. 324, pl. xxiii. fig. 1.

N. Nigeria, Gold Coast, Togoland.

4. Gonionotophis microps Bouleng. Ann. & Mag. N. H. (8) viii. 1911, p. 370.

Cameroon.

10. SIMOCEPHALUS.

Günth. Cat. Col. Sn. p. 194 ; Bouleng. Cat. Sn. i. p. 344.

Synopsis of the Species.

I. Scales in 15 rows on body ; temporals 1+2 (rarely 1+3).
A. Eye much larger than nostril.
1. Ventrals 203–255 ; subcaudals 45–70.
a. 2 labials (3rd and 4th) entering the eye.
Scales with parallel secondary keels or tubercles : loreal present. *S. capensis.*
Scales with strong striation directed obliquely towards the keel ; loreal absent ... . *S. phyllopholis.*
b. 3 labials (3rd, 4th, 5th) entering the eye, unless 5th separated by a subocular detached from it.
Scales strongly keeled, with strong striation directed obliquely towards the keel .... *S. guirali.*
Scales feebly keeled .... *S. baumanni.*
2. Ventrals 239–262 ; subcaudals 75–124 ; scales without secondary keels .... *S. poensis.*
3. Ventrals 178 ; subcaudals 62 .... *S. rostralis.*
B. Eye scarcely larger than the nostril ; scales feebly keeled ; ventrals 205–228 ; subcaudals 49–59 .... *S. stenophthalmus.*

II. Scales in 17 or 19 rows on body ; ventrals 229–231 ; subcaudals 53–68.
Scales in 17 rows ; temporals 2+3.. *S. crossi.*
Scales in 19 rows ; temporals 1+2.. *S. riggenbachi.*

1. SIMOCEPHALUS CAPENSIS.

Heterolepis capensis A. Smith, Ill. Zool. S. Afr., Rept. pl. lv.
Simocephalus capensis Bouleng. t. c. p. 345.

Gaboon, E. Africa, Nyassaland, Natal.

2. SIMOCEPHALUS PHYLLOPHOLIS Werner, Zool. Anz. xxiv. 1901, p. 301.

Cameroon.

3. SIMOCEPHALUS GUIRALI.

Heterolepis guirali Mocquard, Bull. Soc. Philom. (7) viii. 1884, p. 145.
Simocephalus guirali Bouleng. t. c. p. 346.

Cameroon to Congo.

4. SIMOCEPHALUS BAUMANNI Sternf. Mitt. Zool. Mus. Berl. iv. 1908, p. 214.

Togoland.

5. SIMOCEPHALUS POENSIS.

Heterolepis poensis A. Smith, Ill. Zool. S. Afr., Rept.
Simocephalus poensis Bouleng. t. c. p. 346.

Sierra Leone to Congo and Uganda.

6. SIMOCEPHALUS ROSTRALIS Sternf. Mitt. Zool. Mus. Berl. v. 1910, p. 63.

Cameroon.

7. SIMOCEPHALUS STENOPHTHALMUS.

Heterolepis stenophthalmus Mocquard, Bull. Soc. Philom. (7) xi. 1887, p. 16, pl. i. fig. 1.
Simocephalus stenophthalmus Bouleng. t. c. p. 347.
Gold Coast, Togoland, Gaboon.

8. SIMOCEPHALUS CROSSI Bouleng. Cat. Sn. iii. p. 618.
S. Nigeria.

9. SIMOCEPHALUS RIGGENBACHI Sternf. Mitt. Zool. Mus. Berl. v. 1910, p. 63.
Cameroon.

11. ZAMENIS.

Wagl. Syst. Amph. p. 188; Bouleng. Cat. Sn. i. p. 379.

1. ZAMENIS DORRI.

Periops dorri Lataste, Le Natural. 1888, p. 227.
Zamenis dorri Bouleng. t. c. p. 410.
Senegal.

12. CHLOROPHIS.

Hallow. Proc. Ac. Philad. 1857, p. 52; Bouleng. Cat. Sn. ii. p. 91.

Synopsis of the Species.

I. No trace of ventral keels; ventrals 152–166; subcaudals 85–99 .... *C. ornatus.*
II. Ventrals with more or less distinct lateral keel.
  A. Anal divided; scales in 15 rows.
Praeocular separated from frontal; body very slender anteriorly; ventrals 175–190; subcaudals 115–190 .... *C. heterolepidotus.*
Praeocular in contact with or narrowly separated from frontal; ventrals 150–182; subcaudals 90–133 .... *C. irregularis.*
  B. Anal entire; ventrals 141–162; subcaudals 75–96.
Scales in 15 rows........ *C. heterodermus.*
Scales in 13 rows........ *C. carinatus.*

1. CHLOROPHIS ORNATUS.

Philothamnus ornatus Bocage, Jorn. Sc. Lisb. ii. 1872, p. 80.
Chlorophis ornatus Bouleng. t. c. p. 93.
Portuguese Guinea, Angola.

2. CHLOROPHIS HETEROLEPIDOTUS.

Ahætulla heterolepidota Günth. Ann. & Mag. N. H. (3) xi. 1863, p. 286.
Chlorophis heterolepidotus Bouleng. t. c. p. 95, pl. v. fig. 3.
Chlorophis gracilis Sternf. Mitt. Zool. Mus. Berl. v. 1910, p. 64.
Gold Coast to Angola, eastwards to the coast of Zanzibar.

3. CHLOROPHIS IRREGULARIS.

Coluber irregularis Leach, in Bowdich, Miss. Ashant. p. 494.
Chlorophis irregularis Bouleng. t. c. p. 96.

Senegambia and Uganda to Damaraland and S. Rhodesia.

4. CHLOROPHIS HETERODERMUS Hallow. Proc. Ac. Philad. 1857, p. 54; Bouleng. t. c. p. 97.

Sierra Leone to Congo, eastwards to L. Tanganyika.

5. CHLOROPHIS CARINATUS Anderss. Bih. Sv. Ak. Handl. xxvii. iv. no. 5, 1901, p. 9.

Cameroon to Congo, eastwards to the Ituri and the Stanley Falls.

13. PHILOTHAMNUS.

A. Smith, Ill. Zool. S. Afr., Rept.; Bouleng. Cat. Sn. ii. p. 98.

Synopsis of the Species.

I. Scales in 15 rows.
A. Subcaudals 110–155.
Temporals usually 2+2; ventrals 166–207 .... *P. semivariegatus.*
Temporals 1+2 or 2+2; ventrals 150–165 .... *P. nitidus.*
Temporals 1+1; ventrals 167–190 .... *P. dorsalis.*
B. Subcaudals 160–175; ventrals 201–220; temporals 1+1 or 1+2 .... *P. thomensis.*
II. Scales in 13 rows; ventrals 186–194; subcaudals 143–153; temporals 1+1 or 1+2 .... *P. girardi.*

1. PHILOTHAMNUS SEMIVARIEGATUS A. Smith, op. cit. pls. lix., lx.; Bouleng. t. c. p. 99.

Tropical and South Africa.

2. PHILOTHAMNUS NITIDUS.

Ahætulla nitida Günth. Ann. & Mag. N. H. (3) xi. 1863, p. 286.
Philothamnus nitidus Bouleng. t. c. p. 100, pl. v. fig. 4.

Lagos to Cameroon.

3. PHILOTHAMNUS DORSALIS Bocage, Jorn. Sc. Lisb. i. 1866, p. 69; Bouleng. t. c. p. 101.

Gaboon to Angola.

4. PHILOTHAMNUS THOMENSIS Bocage, Jorn. Sc. Lisb. ix. 1882, p. 11, fig.; Bouleng. t. c. p. 101.

S. Thomé Id., Gulf of Guinea.

5. PHILOTHAMNUS GIRARDI Bocage, Jorn. Sc. Lisb. (2) iii. 1893, p. 47; Bouleng. t. c. p. 102.

Anno Bom Id., Gulf of Guinea.

14. GASTROPYXIS.

Cope, Proc. Ac. Philad. 1860, p. 556; Bouleng. Cat. Sn. ii. p. 102.

Two species:—

Ventrals 150–174; subcaudals 129–172	*G. smaragdina.*
Ventrals 185–191; subcaudals 170–177	*G. principis.*

1. GASTROPYXIS SMARAGDINA.

Dendrophis smaragdina Schleg. Phys. Serp. ii. p. 237.
Gastropyxis smaragdina Bouleng. t. c. p. 103.

Tropical Africa, from Sierra Leone and Uganda to the Congo and Northern Angola.

2. GASTROPYXIS PRINCIPIS Bouleng. Ann. Mus. Genova, (3) ii. 1906, p. 213, fig.

Prince's Id., Gulf of Guinea.

15. HAPSIDOPHRYS.

Fischer, Abh. Nat. Ver. Hamb. iii. 1856, p. 110; Bouleng. Cat. Sn. ii. p. 103.

1. HAPSIDOPHRYS LINEATA Fischer, t. c. p. 111, pl. ii. fig. 5; Bouleng. t. c. p. 104.

Gold Coast to Congo, eastwards to Uganda and L. Tanganyika.

16. THRASOPS.

Hallow. Proc. Ac. Philad. 1857, p. 67; Bouleng. Cat. Sn. ii. p. 104.

Two species:—

Rostral little broader than deep; ventrals 179–215; subcaudals 128–146	*T. flavigularis.*
Rostral much broader than deep; ventrals 163–174; subcaudals 101–114	*T. batesii.*

1. THRASOPS FLAVIGULARIS.

Dendrophis flavigularis Hallow. Proc. Ac. Philad. 1852, p. 205.
Thrasops flavigularis Bouleng. t. c. p. 105.

Sierra Leone to Congo.

2. THRASOPS BATESII Bouleng. Ann. & Mag. N. H. (8) ii. 1908, p. 92.

Cameroon.

17. RHAMNOPHIS.

Günth. Ann. & Mag. N. H. (3) ix. 1862, p. 129; Bouleng. Cat. Sn. iii. p. 632.

Two species:—

Scales smooth; a pair of large shields behind the parietals	*R. æthiops.*
Scales more or less distinctly keeled on the middle of the back; no large occipital shields	*R. jacksonii.*

1. RHAMNOPHIS ÆTHIOPS Günth. l. c. pl. x.; Bouleng. l. c.

Thrasops splendens Anderss. Bih. Sv. Ak. Handl. xxvii. iv. no. 5, 1901, p. 11.

Sierra Leone to Congo, eastwards to the Ituri.

2. RHAMNOPHIS JACKSONII.

Thrasops jacksonii Günth. Ann. & Mag. N. H. (6) xv. 1895 p. 528.

Rhamnophis jacksonii Bouleng. l. c.

French Guinea, Gold Coast, eastwards to Uganda and L. Tanganyika.

18. CORONELLA.

Laur. Syn. Rept. p. 84; Bouleng. Cat. Sn. ii. p. 188.

Two species:—

Scales in 21 rows; rostral much broader than deep .... *C. semiornata.*
Scales in 19 rows; rostral a little broader than deep .... *C. coronata.*

1. CORONELLA SEMIORNATA Peters, Mon. Berl. Ac. 1854, p. 622; Bouleng. t. c. p. 195.

Zamenis tchadensis Chaban. Bull. Mus. Paris, 1917, p. 451, fig.

Soudan, East Africa, N. Rhodesia.

2. CORONELLA CORONATA.

Calamaria coronata Schleg. Phys. Serp. ii. p. 46.

Coronella coronata Bouleng. t. c. p. 196.

Senegal to Gold Coast.

19. GRAYIA.

Günth. Cat. Col. Sn. p. 50; Bouleng. Cat. Sn. ii. p. 188.

Synopsis of the Species.

I. Scales in 17 or 19 rows; ventrals 143–168.

Lower anterior temporal longer than its distance from the loreal; 7 upper labials (rarely 8); subcaudals 89–162 .... *G. smythii.*
Lower anterior temporal not longer than its distance from the loreal; 8 or 9 upper labials; subcaudals 71–84 .... *G. ornata.*

II. Scales in 15 rows; ventrals 125–149.

Eye much shorter than snout; subcaudals 100–128 .... *G. thollomi.*
Eye as long as snout; subcaudals 125–161 .... *G. caesar.*

1. GRAYIA SMYTHII.

Coluber smythii Leach, in Tuckey's Explor. R. Zaire, App. p. 409.

Grayia smythii, part., Bouleng. l. c.

Gold Coast to Angola, eastwards to Uganda and L. Tanganyika.

2. GRAYIA ORNATA.

Macrophis ornatus Bocage, Jorn. Sc. Lisb. i. 1866, p. 67.

Grayia ornata Bouleng. P. Z. S. 1909, p. 944, fig.

Cameroon to Angola, eastwards to the Ituri and Lake Tanganyika.

3. Grayia thollοni Mocquard, Bull. Soc. Philom. (8) ix. 1897, p. 11; Bouleng. t. c. p. 951, fig.

French Congo, Katanga, Uganda, Egyptian Soudan.

4. Grayia cæsar.

Xenurophis cæsar Günth. Ann. & Mag. N. H. (3) xii. 1863, p. 357, pl. vi. fig. C; Bouleng. Cat. Sn. ii. p. 288.

Cameroon to Congo, eastwards to the Ituri.

20. Prosymna.

Gray, Cat. Sn. p. 80; Bouleng. Cat. Sn. ii. p. 246.

Two species:—

Two internasals, two præfrontals .... *P. greigerti.*
A single internasal, a single præfrontal .... *P. meleagris.*

1. Prosymna greigerti Mocquard, Bull. Mus. Paris, 1906, p. 466.

French Soudan.

2. Prosymna meleagris.

Calamaria meleagris Reinh. Vid. Selsk. Skr. x. 1843, p. 238, pl. i. figs. 4–6.
Prosymna meleagris Bouleng. t. c. p. 249.

Sierra Leone to S. Nigeria, eastwards to the Egyptian Soudan.

21. Scaphiophis.

Peters, Mon. Berl. Ac. 1870, p. 644; Bouleng. Cat. Sn. ii. p. 254.

1. Scaphiophis albopunctatus Peters, t. c. p. 645, pl. i. fig. 4; Bouleng. l. c.

Tropical Africa, from the Soudan to the Congo.

22. Pœcilopholis.

Bouleng. Ann. & Mag. N. H. (7) xii. 1903, p. 352.

1. Pœcilopholis cameronensis Bouleng. l. c.

Cameroon.

23. Dasypeltis.

Wagl. Syst. Amph. p. 178; Bouleng. Cat. Sn. ii. p. 353.

Two species:—

Eye less than $\frac{1}{5}$ length of head; scales in 23 to 27 rows .... *D. scabra.*
Eye $\frac{1}{3}$ to $\frac{1}{4}$ length of head; scales in 20 to 24 rows .... *D. macrops*

1. Dasypeltis scabra.

Coluber scaber Linn. S. N. i. p. 384.
Dasypeltis scabra Bouleng. t. c. p. 354.
From Sierra Leone and Egypt to the Cape of Good Hope.

2. Dasypeltis macrops Bouleng. Ann. & Mag. N. H. (7) xix. 1907, p. 324.

Cameroon.

B. Opisthoglypha.

I. Eye moderate or large; head more or less distinct from neck; loreal present.

A. Pupil vertically elliptic; head short, much broader than neck.

1. Subcaudals in two rows.

Vertebral scales not enlarged; scales in 19 to 23 rows; two superposed anterior temporals .... *Tarbophis.*
Vertebral scales not enlarged; scales in 17 or 19 rows; a single anterior temporal .... *Leptodira.*
Vertebral scales enlarged; scales in 19 to 25 rows .... *Dipsadomorphus.*

2. Subcaudals single; scales in 17 or 19 rows .... *Dipsadoboa.*

B. Pupil round, exceptionally vertically subelliptic.

1. Scales not oblique, in 17 or 19 rows; loreal not longer than deep.

Scales keeled; anal entire; a single anterior temporal .... *Geodipsas.*
Scales grooved in the adult; anal divided; two loreals; frontal at least twice as long as broad .... *Cœlopeltis.*
Scales smooth; anal divided; frontal about twice as long as broad .... *Rhamphiophis.*

2. Scales more or less oblique, in 15 or 17 (rarely 19) rows, smooth; loreal at least 1½ times as long as deep; rostral not or but little broader than deep.

Frontal, in the middle, not or but slightly narrower than supraocular; a single anterior temporal .... *Dromophis.*
Frontal, in the middle, narrower than supraocular; usually two superposed anterior temporals .... *Psammophis.*

3. Scales not oblique, in 19 to 25 rows, smooth; loreal at least 1½ times as long as deep; rostral at least twice as broad as deep .... *Macroprotodon.*

4. Scales very oblique, very narrow, in 19 or 21 rows, more or less keeled; nostril in an undivided nasal .... *Dispholidus.*

C. Pupil horizontal; scales narrow, oblique, feebly keeled, in 19 rows; nostril in an undivided nasal .... *Thelotornis.*

II. Eye small or very small; head not at all distinct from neck; no loreal; scales in 15 or 17 rows, not oblique.

A. Subcaudals in two rows.

Nasal in contact with rostral; 5th upper labial in contact with parietal; scales in 17 rows; ventrals 173–208 .... *Calamelaps.*
First labial in contact with internasal; no labial in contact with parietal; scales in 15 rows; ventrals 180–249 .... *Miodon.*
First labial in contact with internasal; 5th upper labial in contact with parietal; scales in 15 rows; ventrals 296 .... *Elapocalamus.*

B. Subcaudals single; one or two upper labials in contact with parietal.

First labial in contact with internasal .... *Polemon.*
Nasal in contact with rostral; posterior maxillary teeth large and strongly grooved .... *Aparallactus.*
Nasal in contact with rostral; posterior maxillary teeth feebly enlarged and feebly grooved .... *Elapops.*

1. Tarbophis.

Fleischm. Dalm. nov. Serp. Gen. p. 17; Bouleng. Cat. Sn. iii. p. 47.

Two species:—

Scales in 19 rows; 7 to 9 upper labials	*T. variegatus.*
Scales in 21 or 23 rows; 9 to 11 upper labials	*T. obtusus.*

1. Tarbophis variegatus.

Dipsas variegata Reinh. Vid. Selsk. Skr. x. 1843, p. 249, pl. i. figs. 15–17.

Tarbophis variegatus Bouleng. t. c. p. 51.

Leptodira probeguini Mocquard, Bull. Mus. Paris, 1902, p. 45.

French Guinea to Cameroon.

2. Tarbophis obtusus.

Coluber obtusus Reuss, Mus. Senckenb. i. 1834, p. 137.

Tarbophis obtusus Bouleng. t. c. p. 52.

Mauritania, Northern Nigeria, Egypt to Somaliland.

2. Leptodira.

Günth. Cat. Col. Sn. p. 165; Bouleng. Cat. Sn. iii. p. 47.

Two species:—

Ventrals 144–180; anal entire; subcaudals 32–54	*L. hotambœia.*
Ventrals 201–225; anal divided; subcaudals 94–121	*L. duchesnii.*

1. Leptodira hotambœia.

Coronella hotambœia Laur. Syn. Rept. p. 85.

Leptodira hotambœia Bouleng. t. c. p. 89.

Tropical and South Africa.

2. Leptodira duchesnii Bouleng. Ann. Mus. Congo, Zool. ii. 1901, p. 10, pl. iv. fig. 1.

Dipsadomorphus viridis Sternf. Mitt. Zool. Mus. Berl. iii. 1908, p. 411, fig.

Dipsadomorphus brevirostris Sternf. l. c.

Cameroon to Congo, eastwards to the Ituri.

3. Dipsadomorphus.

Fitzing. in Tschudi, Faun. Per., Herp. p. 55; Bouleng. Cat. Sn. iii. p. 59.

Two species:—

Scales in 19 rows; ventrals 236–276; anal entire; subcaudals 96–132	*D. pulverulentus.*
Scales in 21 to 25 rows; ventrals 240–289; anal divided; subcaudals 122–147	*D. blandingii.*

1. Dipsadomorphus pulverulentus.

Dipsas pulverulenta Fisch. Abh. Nat. Ver. Hamb. iii. 1856, p. 81, pl. iii. fig. 1.

Dipsadomorphus pulverulentus Bouleng. t. c. p. 68.

Dipsadomorphus boueti Chabau. Bull. Mus. Paris, 1916, p. 314, fig.

Sierra Leone to Congo, eastwards to the Ituri.

2. Dipsadomorphus blandingii.

Dipsas blandingii Hallow. Proc. Ac. Philad. 1844, p. 170.

Dipsadomorphus blandingii Bouleng. t. c. p. 77.

Senegambia to Congo, eastwards to Uganda.

4. Dipsadoboa.

Günth. Cat. Col. Sn. p. 182; Bouleng. Cat. Sn. iii. p. 81.

Two species:—

Scales in 17 rows, vertebrals strongly enlarged	*D. unicolor.*
Scales in 19 rows, vertebrals scarcely enlarged	*D. isolepis.*

1. Dipsadoboa unicolor Günth. op. cit. p. 183; Bouleng. l. c.

Sierra Leone to Congo, eastwards to the Ituri.

2. Dipsadoboa isolepis Bouleng. Ann. & Mag. N. H. (7) xix. 1907, p. 325.

Cameroon.

5. Geodipsas.

Bouleng. Cat. Sn. iii. p. 32.

1. Geodipsas depressiceps.

Tropidonotus depressiceps Wern. Verh. zool.-bot. Ges. Wien, xlvii. 1897, p. 135.

Geodipsas mapajensis Anderss. Bih. Sv. Ak. Handl. xxvii. iv. no. 5, 1901, p. 19.

Geodipsas depressiceps Sternf. Mitt. Zool. Mus. Berl. iii. 1908, p. 410.

Cameroon, Fernando Po, Ituri.

6. Cœlopeltis.

Wagl. Syst. Amph. p. 189; Bouleng. Cat. Sn. iii. p. 141.

1. Cœlopeltis monspessulana.

Coluber monspessulanus Hermann, Obs. Zool. i. p. 283.

Cœlopeltis monspessulanus Bouleng. l. c.

Borders of the Mediterranean, southwards to Mauritania, eastwards to Persia.

7. Rhamphiophis.

Peters, Mon. Berl. Ac. 1854, p. 624; Bouleng. Cat. Sn. iii. p. 144.

Two species :—

Snout with angular horizontal edge, curved in profile; 2 or 3 superposed anterior temporals; subcaudals 90–110 .... *R. oxyrhynchus.*
Snout obtusely pointed; 1 or 2 anterior temporals; subcaudals 64–88 .... *R. togoensis.*

1. RHAMPHIOPHIS OXYRHYNCHUS.

Psammophis oxyrhynchus Reinh. Vid. Selsk. Skr. x. 1843, p. 244.
Rhamphiophis oxyrhynchus Bouleng. t. c. p. 146.

Tropical Africa, as far north as the Gold Coast.

2. RHAMPHIOPHIS TOGOENSIS.

Psammophis togoensis Matschie, Mitth. Deutsch. Schutzgeb. vi. 1893, p. 212.
Rhamphiophis togoensis Bouleng. t. c. p. 147.

Togoland, N. Nigeria.

8. DROMOPHIS.

Peters, Mon. Berl. Ac. 1869, p. 447; Bouleng. Cat. Sn. iii. p. 149.

Two species :—

Scales in 17 rows; ventrals 140–159; subcaudals 78–105 .... *D. lineatus.*
Scales in 15 rows; ventrals 161–180; subcaudals 110–122 .... *D. præornatus.*

1. DROMOPHIS LINEATUS.

Dryophylax lineatus Dum. & Bibr. Erp. Gén. vii. p. 1124.
Dromophis lineatus Bouleng. l. c.

Coast of Guinea to Egyptian Soudan and Zanzibar Coast.

2. DROMOPHIS PRÆORNATUS.

Dendrophis præornatus Schleg. Phys. Serp. ii. p. 236.
Dromophis præornatus Bouleng. t. c. p. 150.

Gold Coast to Niger.

9. PSAMMOPHIS.

Boie, Isis, 1827, p. 521; Bouleng. Cat. Sn. iii. p. 152.

Synopsis of the Species.

I. Rostral well visible from above; snout 1⅓ to 2 times as long as eye; subcaudals 64–149.

A. Frontal narrower than the supraocular; anal divided.

Loreal 3 to 4 times as long as deep; usually 9 upper labials, 5th and 6th entering the eye .... *P. schokari.*
Loreal 1⅔ to 2½ times as long as deep; usually 8 upper labials, 4th and 5th entering the eye .... *P. sibilans.*

B. Frontal as broad as the supraocular; loreal 2½ times as long as deep; 8 upper labials, 4th and 5th entering the eye; anal entire .... *P. regularis.*

II. Rostral scarcely visible from above; snout 2 to 2½ times as long as eye; loreal 3 to 4 times as long as deep; 9 upper labials, 5th and 6th entering the eye; subcaudals 144–172 ... *P. elegans.*

1. PSAMMOPHIS SCHOKARI.

Coluber schokari Forsk. Descr. Anim. p. 14.
Psammophis schokari Bouleng. t. c. p. 157.

North Africa to Mauritania and Somaliland; Arabia and Syria to Afghanistan and Sind.

2. PSAMMOPHIS SIBILANS.

Coluber sibilans Linn. S. N. i. p. 383.
Psammophis sibilans Bouleng. t. c. p. 161.

Tropical and South Africa, Egypt.

3. PSAMMOPHIS REGULARIS Sternf. Mitt. Zool. Mus. Berl. iii. 1908, p. 412.

Cameroon and Togoland.

4. PSAMMOPHIS ELEGANS.

Coluber elegans Shaw, Zool. iii. p. 536.
Psammophis elegans Bouleng. t. c. p. 167.

Mauritania to Niger.

10. MACROPROTODON.

Guichen. Explor. Sc. Alg., Rept. p. 22; Bouleng. Cat. Sn. iii. p. 175.

1. MACROPROTODON CUCULLATUS.

Coluber cucullatus I. Geoffr. Descr. Égypte, Rept. pp. 148, 151, pl. viii. fig. 3.
Macroprotodon cucullatus Bouleng. l. c.

Mauritania, North Africa, S. Spain, Baleares, Lampedusa, S. Palestine.

11. DISPHOLIDUS.

Duvernoy, Ann. Sc. Nat. xxvi. 1832, p. 150; Bouleng. Cat. Sn. iii. p. 186.

1. DISPHOLIDUS TYPUS.

Bucephalus typus A. Smith, Zool. Journ. iv. 1829, p. 441.
Dispholidus typus Bouleng. t. c. p. 187.

Tropical and South Africa, northwards to Portuguese Guinea and Abyssinia.

12. THELOTORNIS.

A. Smith, Ill. Zool. S. Afr., Rept.; Bouleng. Cat. Sn. iii. p. 184.

1. THELOTORNIS KIRTLANDII.

Leptophis kirtlandii Hallow. Proc. Ac. Philad. 1844, p. 62.
Thelotornis kirtlandii Bouleng. t. c. p. 185.

Tropical and South Africa, northwards to Sierra Leone and Uganda.

13. CALAMELAPS.

Günth. Ann. & Mag. N. H. (3) xviii. 1866, p. 26; Bouleng. Cat. Sn. iii. p. 245.

Two species:—

Scales in 17 rows; 6 upper labials, 3rd and 4th entering the eye ……	*C. unicolor.*
Scales in 15 rows; 5 upper labials, 2nd and 3rd entering the eye ……	*C. feæ.*

1. CALAMELAPS UNICOLOR.

Calamaria unicolor Reinh. Vid. Selsk. Skr. x. 1843, p. 236, pl. i. figs. 1–3.

Calamelaps unicolor Bouleng. l. c.

Sierra Leone to Niger; East Africa.

2. CALAMELAPS FEÆ Bouleng. Ann. Mus. Genova, (3) ii. 1906, p. 214, fig.

Portuguese Guinea.

14. MIODON.

A. Dum. Arch. Mus. x. 1859, p. 206; Bouleng. Cat. Sn. iii. p. 249.

Synopsis of the Species.

I. Anal entire; ventrals 190–216 …………………………………	*M. acanthias.*
II. Anal divided.	
Internasals considerably shorter than the præfrontals; nasal divided; ventrals 201–228 ………………………………………………	*M. collaris.*
Internasals as long as or slightly shorter than the præfrontals; nasal entire or incompletely divided; ventrals 214–249………………	*M. gabonensis.*
Internasals as long as or slightly shorter than the præfrontals; nasal divided; ventrals 181–214………………………………………	*M. notatus.*

1. MIODON ACANTHIAS.

Urobelus acanthias Reinh. Vid. Meddel. 1860, p. 229, pl. iii.

Miodon acanthias Bouleng. t. c. p. 250.

Gold Coast, Ashantee, Nigeria.

2. MIODON COLLARIS.

Microsoma collare Peters, Sitzb. Ges. Naturf. Fr. Berl. 1881, p. 148.

Miodon collaris Bouleng. t. c. p. 251.

Old Calabar to Angola.

3. MIODON GABONENSIS.

Elapomorphus gabonensis A. Dum. Rev. et Mag. Zool. (2) viii. 1856, p. 468.

Miodon gabonensis Bouleng. t. c. p. 252.

Old Calabar to Congo, eastwards to the Ituri.

4. **Miodon notatus.**

Microsoma notatum Peters, Sitzb. Ges. Nat. Fr. Berl. 1882, p. 127.

Miodon notatus Bouleng. t. c. p. 252.

Cameroon, Congo.

15. ELAPOCALAMUS.

Bouleng. Ann. & Mag. N. H. (8) viii. 1911, p. 371.

1. **Elapocalamus gracilis** Bouleng. l. c.

Cameroon.

16. POLEMON.

Jan, Rev. et Mag. Zool. (2) x. 1858, p. 520; Bouleng. Cat. Sn. iii. p. 253.

Two species:—

A single postocular; ventrals 221–226 .... *P. barthi.*
Two postoculars; ventrals 174–206 .... *P. bocourti.*

1. **Polemon barthii** Jan, l. c.; Bouleng. t. c. p. 254.

Gold Coast, Ashantee.

2. **Polemon bocourti** Mocquard, Bull. Soc. Philom. (8) ix. 1897, p. 13.

Aparallactus hagmanni Gough, Zool. Anz. xxv. 1902, p. 646.

Cameroon, French Congo.

17. APARALLACTUS.

A. Smith, Ill. Zool. S. Afr., Rept., App. p. 15; Bouleng. Cat. Sn. iii. p. 255.

Synopsis of the Species.

I. Two præfrontals; a single labial in contact with the parietal; ventrals 139–156.
A. 6th upper labial in contact with the parietal; 2 postoculars.
Frontal not 1½ times as long as broad .... *A. dolloi.*
Frontal 1½ times as long as broad .... *A. batesii.*
B. 5th upper labial in contact with the parietal; a single postocular.
Frontal at least twice as long as broad .... *A. nigrocollaris.*
Frontal hardly 1½ times as long as broad .... *A. roucheti.*
II. A single præfrontal; 5th and 6th labials in contact with the parietal; ventrals 152–170.
Scales smooth; frontal 1½ times as long as broad .... *A. lineatus.*
Scales smooth; frontal 1⅔ times as long as broad .... *A. anomalus.*
Scales keeled on posterior part of body and on tail; frontal 1½ times as long as broad .... *A. niger.*

1. **Aparallactus dolloi** Werner, Verh. zool.-bot. Ges. Wien, lii. 1902, p. 346.

French Congo.

2. **Aparallactus batesii** Bouleng. Ann. & Mag. N. H. (7) xix. 1907, p. 325.

Cameroon.

3. APARALLACTUS NIGROCOLLARIS Chaban. Bull. Mus. Paris, 1916, p. 377, fig.

French Congo.

4. APARALLACTUS ROUCHETI.

Aparallactus nigrocollaris, var. *roucheti* Chaban. t. c. p. 378, fig.

French Congo.

5. APARALLACTUS LINEATUS.

Uriechis lineatus Peters, Mon. Berl. Ac. 1870, p. 643, pl. i. fig. 3.

Aparallactus lineatus Bouleng. Cat. Sn. iii. p. 261.

Keta, Guinea.

6. APARALLACTUS ANOMALUS.

Uriechis anomala Bouleng. Ann. & Mag. N. H. (6) xii. 1893, p. 273.

Aparallactus anomalus Bouleng. Cat. Sn. iii. p. 262, pl. xi. fig. 3.

Gold Coast.

7. APARALLACTUS NIGER Bouleng. Ann. & Mag. N. H. (6) xix. 1897, p. 154.

Bouleophis chevalieri Chaban. Bull. Mus. Paris, 1916, p. 379, fig.

Sierra Leone, French Guinea.

18. ELAPOPS.

Günth. Ann. & Mag. N. H. (3) iv. 1859, p. 161; Bouleng. Cat. Sn. iii. p. 262.

1. ELAPOPS MODESTUS Günth. l. c.; Bouleng. l. c.

Aparallactus boulengeri Werner, Verh. zool.-bot. Ges. Wien, xlvi. 1896, p. 363.

Aparallactus peraffinis Werner, op. cit. xlvii. 1897, p. 404.

Liberia to Congo, eastwards to the Ituri.

C. **Proteroglypha.**

(Loreal absent in all the genera.)

I. Head short; subcaudals less than 95.	
Scales not at all oblique; ventrals 192–230; subcaudals 67–80	*Boulengerina.*
Scales more or less oblique; ventrals 141–172; subcaudals 13–36...	*Elapechis.*
Scales oblique; ventrals 189–228; subcaudals 50–92	*Naia.*
II. Head long, narrow, snout not broader than long; scales very oblique; ventrals 202–279; subcaudals 97–121	*Dendraspis.*

1. BOULENGERINA.

Dollo, Bull. Mus. Belg. iv. 1886, p. 159; Bouleng. Cat. Sn. iii. p. 357.

Two species:—

Rostral nearly as deep as broad; temporals 1+2; 3 upper labials in contact with lower subocular..	*B. annulata.*
Rostral much broader than deep; temporals 2+2 or 2+3; 2 upper labials in contact with lower subocular	*B. dybowskii.*

4. Miodon notatus.

Microsoma notatum Peters, Sitzb. Ges. Nat. Fr. Berl. 1882, p. 127.

Miodon notatus Bouleng. t. c. p. 252.

Cameroon, Congo.

15. Elapocalamus.

Bouleng. Ann. & Mag. N. H. (8) viii. 1911, p. 371.

1. Elapocalamus gracilis Bouleng. l. c.

Cameroon.

16. Polemon.

Jan, Rev. et Mag. Zool. (2) x. 1858, p. 520; Bouleng. Cat. Sn. iii. p. 253.

Two species:—

A single postocular; ventrals 221–226	*P. barthi.*
Two postoculars; ventrals 174–206	*P. bocourti.*

1. Polemon barthii Jan, l. c.; Bouleng. t. c. p. 254.

Gold Coast, Ashantee.

2. Polemon bocourti Mocquard, Bull. Soc. Philom. (8) ix. 1897, p. 13.

Aparallactus hagmanni Gough, Zool. Anz. xxv. 1902, p. 646.

Cameroon, French Congo.

17. Aparallactus.

A. Smith, Ill. Zool. S. Afr., Rept., App. p. 15; Bouleng. Cat. Sn. iii. p. 255.

Synopsis of the Species.

I. Two præfrontals; a single labial in contact with the parietal; ventrals 139–156.	
A. 6th upper labial in contact with the parietal; 2 postoculars.	
Frontal not 1½ times as long as broad	*A. dolloi.*
Frontal 1½ times as long as broad	*A. batesii.*
B. 5th upper labial in contact with the parietal; a single postocular.	
Frontal at least twice as long as broad	*A. nigrocollaris.*
Frontal hardly 1½ times as long as broad	*A. roucheti.*
II. A single præfrontal; 5th and 6th labials in contact with the parietal; ventrals 152–170.	
Scales smooth; frontal 1⅓ times as long as broad	*A. lineatus.*
Scales smooth; frontal 1⅔ times as long as broad	*A. anomalus.*
Scales keeled on posterior part of body and on tail; frontal 1½ times as long as broad	*A. niger.*

1. Aparallactus dolloi Werner, Verh. zool.-bot. Ges. Wien, lii. 1902, p. 346.

French Congo.

2. Aparallactus batesii Bouleng. Ann. & Mag. N. H. (7) xix. 1907, p. 325.

Cameroon.

3. Aparallactus nigrocollaris Chaban. Bull. Mus. Paris, 1916, p. 377, fig.

French Congo.

4. Aparallactus roucheti.

Aparallactus nigrocollaris, var. *roucheti* Chaban. t. c. p. 378, fig.

French Congo.

5. Aparallactus lineatus.

Uriechis lineatus Peters, Mon. Berl. Ac. 1870, p. 643, pl. i. fig. 3.
Aparallactus lineatus Bouleng. Cat. Sn. iii. p. 261.
Keta, Guinea.

6. Aparallactus anomalus.

Uriechis anomala Bouleng. Ann. & Mag. N. H. (6) xii. 1893, p. 273.

Aparallactus anomalus Bouleng. Cat. Sn. iii. p. 262, pl. xi. fig. 3.
Gold Coast.

7. Aparallactus niger Bouleng. Ann. & Mag. N. H. (6) xix. 1897, p. 154.

Bouleophis chevalieri Chaban. Bull. Mus. Paris, 1916, p. 379, fig.
Sierra Leone, French Guinea.

18. Elapops.

Günth. Ann. & Mag. N. H. (3) iv. 1859, p. 161; Bouleng. Cat. Sn. iii. p. 262.

1. Elapops modestus Günth. l. c.; Bouleng. l. c.

Aparallactus boulengeri Werner, Verh. zool.-bot. Ges. Wien, xlvi. 1896, p. 363.

Aparallactus peraffinis Werner, op. cit. xlvii. 1897, p. 404.
Liberia to Congo, eastwards to the Ituri.

C. **Proteroglypha.**

(Loreal absent in all the genera.)

I. Head short; subcaudals less than 95.
Scales not at all oblique; ventrals 192–230; subcaudals 67–80...... *Boulengerina.*
Scales more or less oblique; ventrals 141–172; subcaudals 13–36... *Elapechis.*
Scales oblique; ventrals 189–228; subcaudals 50–92 .... *Naia.*
II. Head long, narrow, snout not broader than long; scales very oblique; ventrals 202–279; subcaudals 97–121 .... *Dendraspis.*

1. Boulengerina.

Dollo, Bull. Mus. Belg. iv. 1886, p. 159; Bouleng. Cat. Sn. iii. p. 357.

Two species:—

Rostral nearly as deep as broad; temporals 1+2; 3 upper labials in contact with lower subocular........ .... *B. annulata.*
Rostral much broader than deep; temporals 2+2 or 2+3; 2 upper labials in contact with lower subocular .... *B. dybowskii.*

1. BOULENGERINA ANNULATA.

Naia annulata Buchh. & Peters, Mon. Berl. Ac. 1876, p. 119.

Boulengerina annulata Bouleng. P. Z. S. 1900, p. 455, pl. xxxii.

Cameroon to Congo, eastwards to the Uellé and the Stanley Falls.

2. BOULENGERINA DYBOWSKII Mocquard, Bull. Soc. Philom. (8) ix. 1897, p. 15.

French Congo.

2. ELAPECHIS.

Bouleng. Cat. Sn. iii. p. 358.

1. ELAPECHIS GUENTHERI.

Elapsoidea guentheri Bocage, Jorn. Sc. Lisb. i. 1866, p. 70, pl. i. fig. 3.

Elapechis guentheri Bouleng. t. c. p. 359.

Elapechis moebiusi Werner, Verh. zool.-bot. Ges. Wien, xlvii. 1897, p. 400.

Togoland, Northern Nigeria, and Uganda to Angola and Nyassaland.

3. NAIA.

Laur. Syn. Rept. p. 90; Bouleng. Cat. Sn. iii. p. 372.

Synopsis of the Species.

I. 19 to 29 scales across the neck, which is dilatable, 17 to 23 across the body; 53–70 subcaudals.	
6th or 7th upper labial largest and deepest, in contact with postoculars; eye separated from the labials by suboculars	*N. haie.*
6th upper labial largest and deepest, in contact with postoculars; 3rd and 4th upper labials entering the eye	*N. melanoleuca.*
3rd or 3rd and 4th upper labials deepest and entering the eye, 6th and 7th not in contact with postoculars	*N. nigricollis.*
II. 15 scales across the neck, which is not dilatable, 13 or 15 across the body; 4th or 3rd and 4th upper labials entering the eye; 87–92 subcaudals	*N. goldii.*

1. NAIA HAIE.

Coluber haie Linn. in Hasselq. Reise Palæst. p. 366.

Naia haie Bouleng. t. c. p. 374.

Borders of the Sahara, East Africa southwards to the Transvaal and Zululand, Palestine, Arabia.

2. NAIA MELANOLEUCA.

Naia haie, var. *melanoleuca* Hallow. Proc. Ac. Philad. 1857, pp. 61, 72.

Naia melanoleuca Bouleng. t. c. p. 376.

Tropical Africa, from the Gold Coast and Uganda to Angola and Nyassaland.

3. NAIA NIGRICOLLIS Reinh. Vidensk. Selsk. Skr. x. 1843, p. 269, pl. iii. figs. 5–7; Bouleng. t. c. p. 378.

Senegambia and Upper Egypt to Bechuanaland and Natal.

4. NAIA GOLDII Bouleng. Ann. & Mag. N. H. (6) xvi. 1895, p. 34, and Cat. t. c. p. 387, pl. xx. fig. 2.

Naia guentheri Bouleng. Cat. t. c. p. 388, pl. xxi.

Sierra Leone to Congo, eastwards to the Ituri and the Kasai.

4. DENDRASPIS.

Schleg. Versl. Zool. Gen. Amsterd. 1848; Bouleng. Cat. Sn. iii. p. 434.

Two species:—

Scales in 15 to 19 rows, outer not shorter than dorsals	*D. jamesonii.*
Scales in 13 rows, outer half as long as dorsals	*D. angusticeps.*

1. DENDRASPIS JAMESONII.

Elaps jamesonii Traill, in Schleg. Phys. Serp., Engl. Transl. p. 179, pl. ii. figs. 19, 20.

Dendraspis jamesonii Bouleng. t. c. p. 436.

Tropical Africa, from Nigeria and Uganda to the Congo and Angola.

2. DENDRASPIS VIRIDIS.

Leptophis viridis Hallow. Proc. Ac. Philad. 1844, p. 172.

Dendraspis viridis Bouleng. t. c. p. 435.

Senegal to Niger and S. Thomé Id., Gulf of Guinea.

Family VIPERIDÆ.

I. Eye moderate or large, usually separated from the upper labials by suboculars.	
A. Upper surface of head with large symmetrical shields; pupil round	*Causus.*
B. Upper surface of head with scales; pupil vertical.	
1. Subcaudals in two rows.	
Lateral scales not smaller than dorsals, without serrated keels	*Bitis.*
Lateral scales smaller than dorsals, disposed obliquely, with serrated keels	*Cerastes.*
2. Subcaudals single; lateral scales smaller than dorsals and more or less oblique or irregular.	
Lateral scales with serrated keels	*Echis.*
Lateral scales without serrated keels; tail prehensile	*Atheris.*
II. Eye minute, with round pupil; upper surface of head with large symmetrical shields; no loreal; a small præocular usually present	*Atractaspis.*

1. CAUSUS.

Wagl. Syst. Amph. p. 172; Bouleng. Cat. Sn. iii. p. 465.

Two species:—

Scales in 15 to 21 rows; subcaudals in two rows	*C. rhombeatus.*
Scales in 13 rows; subcaudals single	*C. lichtensteinii.*

1. CAUSUS RHOMBEATUS.

Sepedon rhombeatus Licht. Verz. Doubl. Mus. Berl. p. 106.

Causus rhombeatus Bouleng. t. c. p. 467.

Tropical and South Africa.

2. Causus lichtensteinii.

Aspidelaps lichtensteinii Jan, Rev. et Mag. Zool. 1859, p. 511.
Causus lichtensteinii Bouleng. t. c. p. 470.

From the Gold Coast and Uganda to the Congo.

2. Bitis.

Gray, Zool. Miscell. p. 69; Bouleng. Cat. Sn. iii. p. 492.

Synopsis of the Species.

One or two series of scales between the nasal and the rostral; 8 to 11 scales across the head, from eye to eye..........................	*B. arietans.*
4 or 5 series of scales between the nasal and the rostral; 13 to 16 scales across the head, from eye to eye; a single enlarged, sometimes horn-like scale above the internasal, in contact with its fellow	*B. gabonica.*
4 to 6 series of scales between the nasal and the rostral; 14 to 16 scales across the head, from eye to eye; 2 or 3 enlarged, horn-like scales above the internasal, usually with small scales between them..........................	*B. nasicornis.*

1. Bitis arietans.

Vipera arietans Merr. Tent. p. 152.
Bitis arietans Bouleng. t. c. p. 493.

Tropical and South Africa, northwards to S. Morocco; Southern Arabia.

2. Bitis gabonica.

Echidna gabonica Dum. & Bibr. Erp. Gén. vii. p. 1428, pl. lxxx. *b*.
Bitis gabonica Bouleng. t. c. p. 499.

Tropical Africa.

3. Bitis nasicornis.

Coluber nasicornis Shaw, Nat. Miscell. iii. pl. xciv.
Bitis nasicornis Bouleng. t. c. p. 500.

Tropical Africa.

3. Cerastes.

Wagl. Syst. Amph. p. 178; Bouleng. Cat. Sn. iii. p. 501.

1. Cerastes cornutus Forsk. Descr. Anim. p. ix; Bouleng. t. c. p. 502.

Borders of the Sahara and Soudan; Arabia and Palestine.

4. Echis.

Merr. Tent. p. 149; Bouleng. Cat. Sn. iii. p. 504.

1. Echis carinatus.

Pseudoboa carinata Schneid. Hist. Amph. ii. p. 285.
Echis carinatus Bouleng. t. c. p. 505.

Desert and sandy districts of Africa north of the Equator; Southern Asia from Transcaspia and Arabia to India.

5. ATHERIS.

Cope, Proc. Ac. Philad. 1862, p. 337; Bouleng. Cat. Sn. iii. p. 508.

Synopsis of the Species.

9–11 scales across head, from eye to eye, 15–17 round eye; 25–36 scales across body .... *A. chlorechis.*
7–9 scales across head, from eye to eye, 10–16 round eye; 15–25 scales across body .... *A. squamiger.*
8–10 scales across head, from eye to eye, 16–17 round eye; 25 scales across body; several erect, horn-like superciliary scales. *A. ceratophorus.*

1. ATHERIS CHLORECHIS.

Vipera chloroechis Schleg. Versl. Ak. Amsterd. iii. 1855, p. 317.
Atheris chlorechis Bouleng. l. c.

Liberia to Gaboon.

2. ATHERIS SQUAMIGER.

Echis squamigera Hallow. Proc. Ac. Philad. 1854, p. 193.
Atheris squamiger Bouleng. t. c. p. 509.

Calabar to Angola, eastwards to Uganda and the Ituri.

3. ATHERIS CERATOPHORUS Werner, Verh. zool.-bot. Ges. Wien, xlv. 1895, p. 194, pl. v. fig. 1; Bouleng. t. c. p. 510.

Togoland, East Africa.

6. ATRACTASPIS.

A. Smith, Ill. Zool. S. Afr., Rept.; Bouleng. Cat. Sn. iii. p. 510.

Synopsis of the Species.

I. Anal divided; all or most of the subcaudals paired.
2nd lower labial separated from its fellow by the chin-shields; scales in 23–27 rows; ventrals 217–257 .... *A. irregularis.*
2nd lower labial forming a suture with its fellow; scales in 19–21 rows; ventrals 308–331 .... *A. reticulata.*
2nd lower labial forming a suture with its fellow; scales in 21–23 rows; ventrals 336–359 .... *A. heterochilus.*

II. Anal entire; all or most of the subcaudals paired.
Scales in 21 rows; ventrals 198–222 .... *A. matschiensis.*
Scales in 29 rows; ventrals 226 .... *A. caudalis.*

III. Anal entire; all or most of the subcaudals single.
A. Postocular in contact with a large temporal.
1. Snout rounded, feebly projecting.
2nd lower labial very large, forming a suture with its fellow; scales in 23–27 rows; ventrals 178–193 .... *A. corpulenta.*
3rd lower labial longest; scales in 21 rows; ventrals 195 .... *A. boulengeri.*
3rd lower labial longest; scales in 19–21 rows; ventrals 251–300 *A. aterrima.*
2. Snout cuneiform; scales in 31 rows; ventrals 240 .... *A. dahomeyensis.*
B. Temporals small, 2 or 3 superposed in front.
Snout cuneiform; upper part of rostral as long as its distance from the frontal; scales in 25 rows; ventrals 210–223 .... *A. micropholis.*
Snout rounded, upper part of rostral much shorter than its distance from the frontal; scales in 25–29 rows; ventrals 214–225 .... *A. watsonii.*

1. ATRACTASPIS IRREGULARIS.

Elaps irregularis Reinh. Vid. Selsk. Skr. x. 1843, p. 264, pl. iii. figs. 1–3.

Atractaspis irregularis Bouleng. t. c. p. 513.

West and Central Africa, from the Gold Coast and Uganda to the Congo.

2. ATRACTASPIS RETICULATA Sjöstedt, Zool. Anz. 1896, p. 516.

Cameroon.

3. ATRACTASPIS HETEROCHILUS Bouleng. Ann. Mus. Congo, Zool. iii. p. 13, pl. v. fig. 1.

Cameroon, Ituri, Tanganyika.

4. ATRACTASPIS MATSCHIENSIS Werner, Verh. zool.-bot. Ges. Wien, xlvii. 1897, p. 404.

Cameroon.

5. ATRACTASPIS CAUDALIS Sternf. Sitzb. Ges. Nat. Fr. Berl. 1908, p. 94.

Gold Coast.

6. ATRACTASPIS CORPULENTA.

Brachycranium corpulentum Hallow. Proc. Ac. Philad. 1854, p. 99.

Atractaspis corpulenta Bouleng. Cat. Sn. iii. p. 514.

Liberia to Congo, eastwards to the Ituri.

7. ATRACTASPIS BOULENGERI Mocquard, Bull. Soc. Philom. (8) ix. 1897, p. 16.

Ogowe.

8. ATRACTASPIS ATERRIMA Günth. Ann. & Mag. N. H. (3) xii. 1863, p. 363; Bouleng. t. c. p. 515.

Gold Coast to Niger, eastwards to Uganda.

9. ATRACTASPIS DAHOMEYENSIS Bocage, Jorn. Sc. Lisb. xi. 1887, p. 196; Bouleng. t. c. p. 516.

Dahomey.

10. ATRACTASPIS MICROPHOLIS Günth. Ann. & Mag. N. H. (4) ix. 1872, p. 36, pl. iii. fig. E; Bouleng. t. c. p. 516.

Senegambia, Northern Nigeria.

11. ATRACTASPIS WATSONII Bouleng, Ann. & Mag. N. H. (8) ii. 1908, p. 93.

Atractaspis nigra Pellegr. Bull. Mus. Paris, 1909, p. 414.

Mauritania, French Soudan, Northern Nigeria.

17. A List of the Snakes of North Africa.

By G. A. Boulenger, F.R.S., F.Z.S.

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This list, dealing with the comparatively few species known from North Africa (Section VII. of map on p. 269), concludes the series I have prepared for the easy identification of the Snakes of Africa*.

Only four families are represented in this area:—

Worm-like, covered with uniform scales above and beneath; mouth small, inferior; eyes rudimentary, under the head-shields......	GLAUCONIIDÆ.
Mouth large; eyes exposed; head covered with small scales; ventral shields much narrower than the body	BOIDÆ.
Mouth large; eyes exposed; head with large shields; ventral shields broad	COLUBRIDÆ.
Mouth large; eyes exposed; head covered with small scales; ventral shields broad..	VIPERIDÆ.

Family GLAUCONIIDÆ.

A single genus.

1. GLAUCONIA.

Gray, Cat. Liz. p. 139; Bouleng. Cat. Sn. i. p. 59.

Two species:—

Snout hooked, the preoral portion flat or concave inferiorly; diameter of body at least 100 times in total length........	*G. macrorhynchus.*
Snout rounded; diameter of body less than 100 times in total length	*G. cairi.*

1. GLAUCONIA MACRORHYNCHUS.

Stenostoma macrorhynchus Jan, Arch. Zool. Anat. Phys. i. 1862, p. 190.

Glauconia macrorhynchus Bouleng. Cat. Sn. i. p. 61.

Glauconia algeriensis Jacquet, Bibl. Anat. iv. 1896, p. 79, figs.

Algeria, Nubia, Mesopotamia, Persia.

2. GLAUCONIA CAIRI.

Stenostoma cairi Dum. & Bibr. Erp. Gén. vi. p. 323.

Glauconia cairi Bouleng. Cat. Sn. i. p. 66.

Egypt, Nubia, Abyssinia, Somaliland, Mauritania.

Family BOIDÆ.

A single genus.

1. ERYX.

Daud. Hist. Rept. vii. p. 251; Bouleng. Cat. Sn. i. p. 122.

* P. Z. S. 1915, pp. 193, 369, 611, 641, and 1919, p. 267.—According to my latest estimate, the number of African species of Snakes amounts to 475.

Two species:—

12 to 15 scales from eye to eye across forehead; tail pointed, ending in a conical scute	*E. thebaicus.*
5 to 7 scales from eye to eye across forehead; tail obtuse	*E. jaculus.*

1. Eryx thebaicus Reuss, Mus Senckenb. i. 1834, p. 134; Bouleng. Cat. Sn. i. p. 125.

Upper Egypt to East Africa.

2. Eryx jaculus.

Anguis jaculus Linn. S. N. i. p. 391.
Eryx jaculus Bouleng. Cat. Sn. i. p. 124.

Algeria, Egypt, Syria, Asia Minor, Greece.

Family COLUBRIDÆ.

Three parallel series:—

No poison-fangs; all the teeth solid	A. Aglypha.
Poison-fangs behind	B. Opisthoglypha.
Poison-fangs in front	C. Proteroglypha.

A. Aglypha.

I. Loreal present; scales in 19 rows or more.	
A. Scales strongly keeled, in 19 to 23 rows; pupil round; a single anterior temporal	*Tropidonotus.*
B. Scales smooth or feebly keeled; 2 to 4 superposed anterior temporals; rostral not twice as broad as deep.	
Head elongate; snout rounded at the end; pupil round; one or more suboculars; ventrals 195–278; subcaudals 65–154	*Zamenis.*
Snout cuneiform, rostral four-sided; pupil vertically elliptic or subelliptic; ventrals 160–188; subcaudals 35–46	*Lytorhynchus.*
Snout rounded or obtusely pointed; pupil round; no suboculars; ventrals 170–200; subcaudals 49–72	*Coronella.*
II. Loreal present or absent; scales in 15 rows, smooth; snout strongly projecting	*Oligodon.*
III. Loreal absent; pupil vertical; scales in 23 to 27 rows, strongly keeled	*Dasypeltis.*

1. Tropidonotus.

Kuhl, Bull. Sc. Nat. ii. 1824, p. 81; Bouleng. Cat. Sn. i. p. 192.

Synopsis of the Species.

Scales in 19 rows; third and fourth upper labials entering the eye; upper postocular not in contact with the temporal	*T. natrix.*
Scales in 19 rows; fourth or fourth and fifth upper labials entering the eye; upper postocular not in contact with the temporal	*T. tessellatus.*
Scales in 21 or 23 rows; third and fourth upper labials entering the eye; upper postocular in contact with the temporal	*T. viperinus.*

1. Tropidonotus natrix.

Coluber natrix Linn. S. N. i. p. 380.

Tropidonotus natrix Bouleng. t. c. p. 219.

Algeria and Tunisia north of the Atlas, Europe, Western Asia.

2. TROPIDONOTUS TESSELLATUS.

Coronella tessellata Laur. Syn. Rept. p. 87.
Tropidonotus tessellatus Bouleng. t. c. p. 233.

N.E. Egypt, Europe, Western Asia.

3. TROPIDONOTUS VIPERINUS.

Coluber viperinus Latr. Hist. Rept. iv. p. 49.
Tropidonotus viperinus Bouleng. t. c. p. 235.

Morocco, Algeria, Tunisia, Spanish Peninsula, France, Switzerland, Italy.

2. ZAMENIS.

Wagl. Syst. Amph. p. 188; Bouleng. Cat. Sn. i. p. 379.

Synopsis of the Species.

I. A pair of internasals and a pair of præfrontals.
  A. Scales in 19 rows; two labials entering the eye.
Frontal anteriorly not or but little broader than the supraocular; ventrals 205–218; subcaudals 98–132 .... *Z. dahlii.*
Frontal anteriorly considerably broader than the supraocular; ventrals 212–262; subcaudals 113–154 .... *Z. rhodorhachis.*
Frontal anteriorly considerably broader than the supraocular; ventrals 195–201; subcaudals 95–105 .... *Z. rogersi.*
  B. Scales in 21 (rarely 23) rows, smooth; two labials entering the eye; ventrals 198–228; subcaudals 79–111 ...... *Z. florulentus.*
  C. Scales in 23 or 25 rows, obtusely or faintly keeled; usually a single labial entering the eye; ventrals 197–216; subcaudals 70–101 .... *Z. nummifer.*
  D. Scales in 25 to 29 (rarely 23) rows, smooth.
Scales usually in 25 rows; usually one labial entering the eye; ventrals 214–232; subcaudals 87–104 .... *Z. algirus.*
Scales in 25 to 29 rows; eye usually separated from the labials by a series of suboculars; ventrals 222–258; subcaudals 77–107 .... *Z. hippocrepis.*
II. Præfrontals broken up into 3 or more shields; eye separated from the labials by suboculars; scales in 25 to 31 rows, usually more or less obtusely keeled; ventrals 210–278; subcaudals 65–110 .... *Z. diadema.*

1. ZAMENIS DAHLII.

Tyria dahlii Fitzing. N. Class. Rept. p. 60.
Zamenis dahlii Bouleng. t. c. p. 397.

N. Egypt, S.W. Asia, S.E. Europe.

2. ZAMENIS RHODORHACHIS Jan, in De Filippi, Viagg. Pers. p. 356; Bouleng. t. c. p. 398.

Egypt to Somaliland, S.W. Asia.

3. ZAMENIS ROGERSI Anders. Ann. & Mag. N. H. (6) xii. 1893, p. 439; Bouleng. Cat. Sn. iii. p. 623.

N. Egypt.

4. ZAMENIS FLORULENTUS.

Coluber florulentus Geoffr. Descr. Egypte, Rept. p. 146, pl. viii. fig. 2.
Zamenis florulentus Bouleng. Cat. Sn. i. p. 402.

Egypt to Somaliland.

5. ZAMENIS NUMMIFER.

Coluber nummifer Reuss, Mus. Senckenb. i. p. 135.
Zamenis nummifer Bouleng. t. c. p. 407.

N. Egypt, Syria, Cyprus, Asia Minor.

6. ZAMENIS ALGIRUS.

Periops algira Jan, Elenco, p. 60.
Zamenis algirus Bouleng. t. c. p. 408.

Algeria and Tunisia.

7. ZAMENIS HIPPOCREPIS.

Coluber hippocrepis Linn. S. N. i. p. 388.
Zamenis hippocrepis Bouleng. t. c. p. 409.

Morocco, Algeria, Tunisia, Spain and Portugal, Sardinia.

8. ZAMENIS DIADEMA.

Coluber diadema Schleg. Phys. Serp. ii. p. 148.
Zamenis diadema Bouleng. t. c. p. 411.

Algeria, Tunisia, Tripoli, Egypt, Arabia to Turkestan and N.W. India.

3. LYTORHYNCHUS.

Peters, Mon. Berl. Ac. 1862, p. 272; Bouleng. Cat. Sn. i. p. 414.

1. LYTORHYNCHUS DIADEMA.

Heterodon diadema Dum. & Bibr. Erp. Gén. vii. p. 779.
Lytorhynchus diadema Bouleng. t. c. p. 415.

Algerian and Tunisian Sahara, Tripoli, Egypt, Nubia, Arabia, Syria, Mesopotamia, Persia.

4. CORONELLA.

Laur. Syn. Rept. p. 84; Bouleng. Cat. Sn. ii. p. 188.

Two species:—

Rostral as deep as broad, produced between the internasals	*C. amaliæ.*
Rostral much broader than deep, just visible from above	*C. girondica.*

1. CORONELLA AMALIÆ.

Rhinechis amaliæ Boettg. Zool. Anz. 1881, p. 570.
Coronella amaliæ Bouleng. t. c. p. 193.
Morocco and Algeria.

2. CORONELLA GIRONDICA.

Coluber girondicus Daud. Hist. Rept. vi. p. 432.
Coronella girondica Bouleng. t. c. p. 194.
Morocco and Algeria, Spain and Portugal, S. France, Italy.

5. OLIGODON.

Boie, Isis, 1827, p. 519; Bouleng. Cat. Sn. ii. p. 233.

1. OLIGODON MELANOCEPHALUS.

Homalosoma melanocephalum Jan, Arch. Zool. Anat. Phys. ii. 1862, p. 34.
Oligodon melanocephalus Bouleng. t. c. p. 246.
N. Egypt, Sinai, Syria.

6. DASYPELTIS.

Wagl. Syst. Amph. p. 178; Bouleng. Cat. Sn. ii. p. 353.

1. DASYPELTIS SCABRA.

Coluber scaber Linn. Mus. Ad. Frid. p. 36, pl. x. fig. 1.
Dasypeltis scabra Bouleng. t. c. p. 354.
Egypt, Tropical and South Africa, S. Arabia.

B. Opisthoglypha.

I. Head short, very distinct from neck; pupil vertically elliptic; scales in 19 to 23 rows; subcaudals 60–86.

Eye moderate; anal divided .... *Tarbophis.*
Eye large; anal entire .... *Leptodira.*

II. Head elongate; eye large, with round pupil; scales in 17 or 19 rows.

Scales not oblique; loreal not longer than deep; subcaudals 48–102 .... *Cœlopeltis.*
Scales more or less oblique; loreal at least $1\frac{2}{3}$ times as long as deep; subcaudals 90–149 .... *Psammophis.*

III. Head short, not very distinct from neck; eye rather small, with round or vertically subelliptic pupil; rostral at least twice as broad as deep; scales in 19 to 25 rows; subcaudals 40–54 .... *Macroprotodon.*

1. TARBOPHIS.

Fleischm. Dalm. nov. Serp. Gen. p. 17; Bouleng. Cat. Sn. iii. p. 47.

Two species:—

Scales in 19 rows; ventrals 174–190	*T. savignyi.*
Scales in 23 (rarely 21) rows; ventrals 213–272	*T. obtusus.*

1. TARBOPHIS SAVIGNYI Bouleng. t. c. p. 48.

N. Egypt, Syria.

2. TARBOPHIS OBTUSUS.

Coluber obtusus Reuss, Mus. Senckenb. i. 1834, p. 137.
Tarbophis obtusus Bouleng. t. c. p. 52.

Egypt to Somaliland, Mauritania and N. Nigeria.

2. LEPTODIRA.

Günth. Cat. Col. Sn. p. 165; Bouleng. Cat. Sn. iii. p. 88.

1. LEPTODIRA TRIPOLITANA Werner, Zool. Jahrb., Syst. xxvii. 1909, p. 619.

Tripoli.

3. CŒLOPELTIS.

Wagl. Syst. Amph. p. 189; Bouleng. Cat. Sn. iii. p. 141.

Two species:—

Two loreals; frontal very narrow in the middle; subcaudals 68–102	*C. monspessulana.*
A single loreal: frontal as broad as the supraocular; subcaudals 48–73	*C. moilensis.*

1. CŒLOPELTIS MONSPESSULANA.

Coluber monspessulanus Herm. Obs. Zool. i. p. 283.
Cœlopeltis monspessulana Bouleng. l. c.

Borders of the Mediterranean, southwards to Mauritania, eastwards to Persia.

2. CŒLOPELTIS MOILENSIS.

Coluber moilensis Reuss, Mus. Senckenb. i. 1834, p. 142, pl. vii. fig. 1.
Cœlopeltis moilensis Bouleng. t. c. p. 143.

Northern Sahara, from Algeria to Egypt, Nubia, Arabia, Western Persia.

4. PSAMMOPHIS.

Boie, Isis, 1827, p. 521; Bouleng. Cat. Sn. iii. p. 152.

Two species:—

Loreal 3 to 4 times as long as deep; usually 9 upper labials, 5th and 6th entering the eye	*P. schokari.*
Loreal 1⅔ to 2½ times as long as deep; usually 8 upper labials, 4th and 5th entering the eye	*P. sibilans.*

1. PSAMMOPHIS SCHOKARI.

Coluber schokari Forsk. Descr. Anim. p. 14.
Psammophis schokari Bouleng. t. c. p. 157.

North Africa to Mauritania and Somaliland; Arabia and Syria to Afghanistan and Sind.

2. PSAMMOPHIS SIBILANS.

Coluber sibilans Linn. S. N. i. p. 383.
Psammophis sibilans Bouleng. t. c. p. 161.

Egypt, Tropical and South Africa.

5. MACROPROTODON.

Guichen. Expl. Sc. Alg., Rept. p. 22; Bouleng. Cat. Sn. iii. p. 175.

1. MACROPROTODON CUCULLATUS.

Coluber cucullatus I. Geoffr. Descr. Egypte, Rept. pp. 148, 151, pl. viii. fig. 3.
Macroprotodon cucullatus Bouleng. l. c.

North Africa from Morocco to N. Egypt, Mauritania, S. Spain, Baleares, Lampedusa, S. Palestine.

C. Proteroglypha.

Two genera:—

Scales oblique; neck dilatable; subcaudals 53–68	*Naia.*
Scales not oblique; subcaudals 45–48	*Walterinnesia.*

1. NAIA.

Laur. Syn. Rept. p. 90; Bouleng. Cat. Sn. iii. p. 372.

Two species:—

6th or 7th upper labial largest and deepest, in contact with postoculars; eye separated from the labials by suboculars; 21–23 scales across neck, 19–21 across middle of body	*N. haie.*
3rd upper labial deepest and entering the eye, 6th and 7th not in contact with postoculars; 25–29 scales across neck, 21–25 across middle of body	*N. nigricollis.*

1. NAIA HAIE.

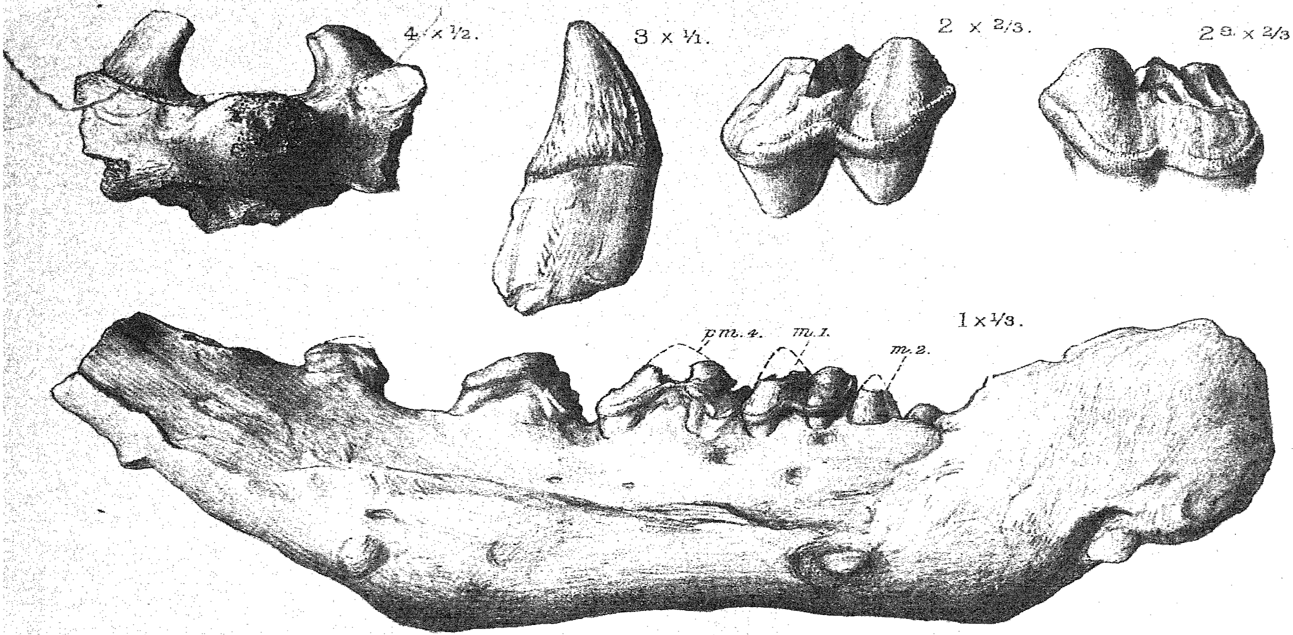
Coluber haie Linn. in Hasselq. Reise Palæst. p. 366.
Naia haie Bouleng. t. c. p. 374.

Borders of the Sahara, East Africa southwards to the Transvaal and Zululand, Palestine, Arabia.

2. NAIA NIGRICOLLIS Reinh. Vid. Selsk. Skr. x. 1843, p. 269, pl. iii. figs. 5–7; Bouleng. t. c. p. 378.

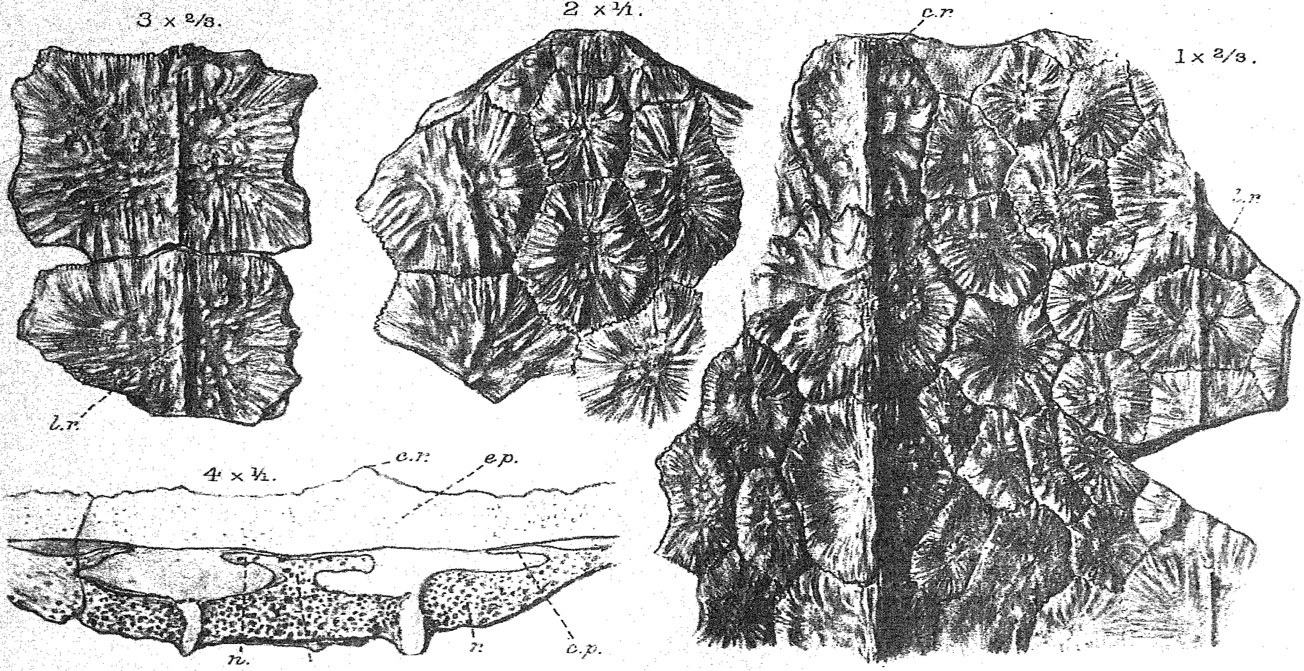
Upper Egypt and Senegambia to Bechuanaland and Natal.

P.Z.S. 1919. ANDREWS. Pl. I.



G.M.Woodward del. et lith.
Huth imp.

PAPPOCETUS LUGARDI.



G. M. Woodward del. et lith.
Huth imp.

COSMOCHELYS DOLLOI.

18. A Description of New Species of Zeuglodont and of Leathery Turtle from the Eocene of Southern Nigeria.

By C. W. ANDREWS, D.Sc., F.R.S. (British Museum, Natural History).

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(Plates I. & II.*)

Two small collections of vertebrate remains from the Ombialla District of Southern Nigeria have recently been received by the British Museum, one having been sent by Sir Frederick Lugard, G.C.M.G., the other by Sir John Eaglesome, K.C.M.G. The sternum of a large carinate bird included in the latter collection has already been described †, and it is now proposed to give a short account of some remains of a Zeuglodont Whale and of a Turtle belonging to the so-called Athecate group.

PAPPOCETUS LUGARDI, gen. et sp. nov.

Portions of the lower jaws of a Zeuglodont are included in both collections, and, although in both cases incomplete, the specimens to some extent supplement one another, so that the structure is fairly clear. The most complete specimen (M 11414, referred to as specimen A) consists of the imperfect left ramus wanting the articular and angular regions, but united with a considerable portion of the anterior region of the right ramus including the hinder part of the symphysis (Pl. I. fig. 1). Portions of five teeth are preserved on the left side and of two on the right. The bones were embedded in an intensely hard pyritous clay, including many fragments of molluscan shells. This may be regarded as the type-specimen.

The other specimen (M 11086, specimen B) is a left ramus of a mandible broken into three pieces (text-fig. 1). The anterior of these bears the sockets for the incisors, canine, and front half of the single-rooted pm_1. Behind this a length of about 2·5 cm., which must have carried the posterior half of pm_1 and anterior half of pm_2, is wanting. The length missing is estimated by comparison with specimen A, which belonged to an individual of nearly the same size. The two other fragments unite below, but, unfortunately, the portion of the alveolar border bearing pm_3 is lost. The hinder piece bears the basal portion of the very large pm_4, and following this without interval are the three molars, of which the first is nearly complete, the second is represented by the roots only, while the third, which had not yet emerged, has been exposed by cutting away the bone; the articular and angular regions are missing.

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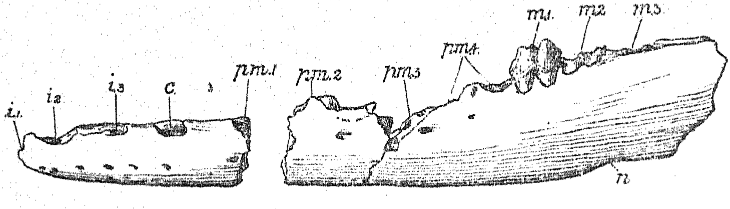
* For explanation of the Plates see p. 319.

† Proc. Zool. Soc. 1916, p. 519.

The outer face of the mandibular ramus is convex from above downwards, the convexity being most marked in the symphysial region, which extends back to the level of the anterior root of pm_3; in *Prozeuglodon* it does not seem to extend beyond the hinder end of pm_2. The symphysial surface itself bears a strongly rugose surface for union with the opposite ramus, the rugosities being most strongly developed posteriorly: the union between the two rami must have been much stronger than in *Zeuglodon* or *Prozeuglodon*, where the symphysial surfaces bear only a few straight and slightly developed longitudinal rugosities. Behind the symphysis the inner face of the ramus is convex from above downwards immediately beneath the alveolar border, but towards the ventral edge becomes gently concave in the same direction. The ventral border is nearly straight from before backwards as far as beneath the hinder end of m_2, where it turns somewhat upwards for a short distance and then continues in the original direction, so that at this point a slight step-like prominence is formed (text-fig. 1, *n*). The posterior portion of the ramus is lost in both specimens. In its general form the mandibular ramus is very similar in form to those of *Prozeuglodon* and *Zeuglodon*, but at the same time is distinguished from them by being more massively constructed and by the presence of the slight step in the ventral border referred to above.

Text-figure 1.



Left ramus of mandible of *Pappocetus lugardi*, gen. et sp. nov.
n, step-like notch on lower border (M 11086). About $\frac{1}{3}$ nat. size.

Teeth.—So far as can be ascertained the dental formula of the mandible was I. 3, C. 1, Pm. 4, M. 3—the full Eutherian dentition. Of these, I_1 is represented in specimen B by the socket only; this is situated at the extreme anterior end of the jaw and was separated from its fellow of the opposite side by a very thin wall of bone only. The tooth must have been directed forwards and somewhat upwards. I_2 and I_3 are represented in the same specimen by their broken bases, which are somewhat wider, from before backwards than from side to side, and appear to have possessed a slight keel on the anterior border. Of the incisors I_2 is much the largest, the longitudinal diameter of its base being about 27 mm., while in I_3 this measurement is only 13 mm.; I_1 was about the same size at I_3. This relatively large size of I_2 seems to be characteristic of this genus, not occurring in

Prozeuglodon or *Zeuglodon*. I_2 follows immediately behind I_1, but between it and I_3 there is interval of about 23 mm. The canine is separated from I_3 by a diastema of 30 mm.; it is represented by its broken base, which shows that it was about the same size as I_2, and was probably somewhat compressed from side to side with an anterior angle; like the incisors it was directed forwards. Behind and a little to the outer side of the lower canine there is a slight depression in the outer surface of the jaw, presumably for the reception of the point of the upper canine. Pm_1 is represented by the anterior half of its broken base in specimen B, and by its socket only in specimen A; it is separated from the canine by an interval of about 45 mm., and was considerably compressed laterally, its long diameter being about 30 mm., the transverse only 14. The remaining teeth are all represented in one or other of the specimens by their more or less broken crowns. Pm_2 is preserved in specimen A only, where it is present on both sides, following pm_1 at an interval of 19 mm. It is a two-rooted tooth, the greatest length of which is 37 mm., while its greatest width above the front of the posterior root is 13 mm. So far as can be made out, the compressed crown formed a single cusp without accessory serrations. Both the anterior and posterior borders of the crown are blunt and rounded; at the base of the crown there is a well-marked constriction and on the inner side there is a slightly developed cingulum. The enamel is much roughened, being raised into knotted ridges, which for the most part run vertically. On the posterior lobe of the tooth the enamel ridges of the outer and inner side meet, forming a keel which is situated rather more on the inner than on the outer side of the crown.

Pm_3 is represented in specimen B by its roots only, but in A is present on both sides, that on the left being nearly complete. It is a long, laterally compressed two-rooted tooth, the length of the crown being 53 mm., its greatest breadth only 15 mm. The crown forms one large cusp, the anterior slope of which is shorter and steeper than the posterior. On the anterior border there seem to have been no accessory cusps, but on the posterior there are two with perhaps a rudimentary basal cusp just above the cingulum, which is well developed on the postero-internal side; it is also distinctly marked on the outer and less clearly on the inner face of the tooth. The summit of the main cusp has undergone considerable wear, which also extended down the anterior edge; the top of the upper accessory cusp is also worn.

Pm_4 is unfortunately represented in specimen B by its two roots only, while in A the crown is very imperfect. It was even more strongly compressed laterally than pm_3, and from before backwards was considerably the longest tooth in the series, measuring 59 mm. in this direction, while from side to side the greatest width (above the posterior root) is only 18 mm. It consisted of a main anterior cusp, which may or may not have borne small accessory cusps, and a posterior heel-like cusp which relationship, and it is interesting to note that probably the ancestors of the Centetidæ lived in Africa in early Tertiary times, and it is there also that the Zeuglodonts probably originated.

COSMOCHELYS DOLLOI, gen. et sp. nov.

The second specimen (R. 4338) now described consists of portions of the central region of a carapace belonging to a Chelonian referable to the so-called Atheeæ, to which belong the recent Leathery Turtle, *Dermochelys coriacea*, and the Tertiary genus *Psephophorus* to which the present form seems to be most nearly allied. This specimen was presented to the Museum by Sir John Eaglesome, K.C.M.G. Unfortunately, the fragments seem to have been picked up at random, so that much has been lost; but, nevertheless, it has been possible to join a certain number of pieces, which together make up a portion of the carapace measuring about 37 cm. long by 27 cm. wide. On the right side of this the upper portions of five ribs are preserved and on the left, three, corresponding to the posterior three on the right side. In the case of these three posterior ribs, the upper portion of their articular ends are preserved, articulating with the neural arches. These bore neural short spines, to the upper ends of which the remnants of the disappearing neurals are joined. The whole outer surface of the carapace is covered by a thick armour of epithecal plates, corresponding to the shell of *Dermochelys*.

This epithecal shell may be described first. As in *Dermochelys* it consists of several rows of longitudinally keeled plates separated by a mosaic of smaller plates without ridges. The keeled plates forming the median dorsal ridge are roughly hexagonal and elongated in a longitudinal direction; they present much the appearance of the neurals of a thecal carapace. The keeled plates of the two upper lateral rows are seen also to be irregularly hexagonal, but shorter than those of the median row. Two or three isolated keeled plates (Pl. II. fig. 3), to which the outer points of ribs are adherent, are much larger than the rest and are nearly quadrate in outline; they were probably near the margin of the carapace and are thinner than the central plates. The exact number of keeled ridges cannot be determined, but there were at least seven. The central part of the carapace preserved shows a median and two lateral ridges, while the large (? marginal) plates above referred to bear another, and others may have been present, since it is unknown how much of the carapace is missing between the outer part of the main fragment and the margin; the distance must have been considerable to allow for the narrowing of the broad ribs towards their outer pointed ends. In *Dermochelys* a median and three lateral ridges are present, seven in all, but Völker * thinks that probably there were originally nine.

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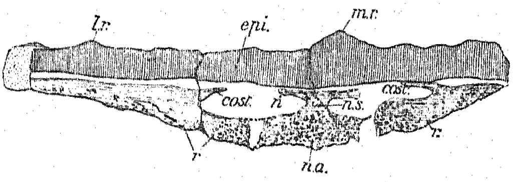
* Völker, "*Dermochelys coriacea*," Zool. Jahrbücher (Anatomie), vol. xxxiii. (1913), p. 477.

The plates filling the intervals between the ridges are smaller than the keeled plates and of more irregular forms (Pl. II. fig. 2). So far as can be seen, between each pair of ridges there are only two rows of these plates, except that here and there a small irregular plate may be intercalated. This comparatively small number of intermediate plates seems to be a primitive character, since in *Psephophorus* and *Dermochelys* there is a progressive increase in their numbers: in *Psephophorus* there were at least six rows and in *Dermochelys* they are very numerous. The epithecal plates are very thick and massive; in the median row the thickness of the lateral portions is about 10 mm., while at the ridge it may be as much as 16 mm. In the lateral plates above noticed, the general thickness has decreased to 7 mm. or, at the ridge, 9 mm. According to Seeley [*], the plates of *Psephophorus* may attain a thickness of nearly 10 mm., but are usually thinner. The outer surface of the plates is beautifully sculptured, with a series of irregular tuberosities in the middle bordered by ridges more or less radially arranged, and running to the margin which is usually bevelled off, so that the suture between neighbouring plates runs at the bottom of a groove. In *Psephophorus* also the surface of the plates is sculptured, but the ornament appears to consist of radial ridges only and to be less pronounced than here. Probably in life the outer surface was covered by a leathery skin, or possibly by horny plates, though this does not seem likely. The presence of this strongly marked ornament seems to show that this Turtle was not adapted for rapid motion through the water, but was probably a littoral or even a swamp-living form like *Trionyx*. It is unfortunate that nothing is known of the plastron.

Text-figure 2.



Transverse section through epithecal and thecal shell of *Cosmochelys*.

cost., costal plate; *epi.*, epithecal shell; *l.r.*, lateral ridge of ditto; *m.r.*, median ridge of ditto; *n.*, neural plate; *n.a.*, neural arch; *n.s.*, neural spine; *r.*, rib. ½ nat. size.

The thecal skeleton, so far as preserved, consists of the remnants of the costals and neurals. The costal plates are confined to the upper end of the ribs, where they are fairly well developed, projecting forwards and backwards so as to unite with one another in a short suture; external to this they narrow rapidly to the edge of the broad and strongly developed rib. Towards the middle line of the carapace the costals are free from the ribs for a short distance, forming flanges which project towards the vestigial neurals, but do not reach them. In this respect the degree of reduction is intermediate between what is seen in *Protostega* and *Archelon*, in which the greatly reduced costals still meet the neurals and unite with one another, and in *Dermochelys*, where the upper borders of the costals, though marked by a distinct ridge, do not form flanges projecting towards the neurals, which are, in fact, absent or perhaps in part represented by the bilobate upper ends of the neural spines; moreover, in *Dermochelys* the costals do not unite with one another. The upper ends of the ribs are thick and no doubt had a considerable articulation with the vertebral centra, but this region is abraded and only the portion articulating with the neural arch remains. The distance between the heads of the ribs of opposite sides is about 33 mm. The most anterior of the ribs preserved appears to be curved backwards towards the rib behind and to have had the costal plate on the hinder side only: this was, probably, the first rib. The outer free portion of the other ribs is very broad and strongly developed.

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[*] Seeley, "Note on *Psephophorus polygonus* v. Meyer," Quart. Journ. Geol. Soc. vol. xxxvi. (1880), p. 406.

The neural arch bears a short stout neural spine, to the upper end of which is attached a thin, flat, table-like neural, which projects on either side for about 7 mm., but remains separated from the upper edge of the costal by an interval of 10 mm.

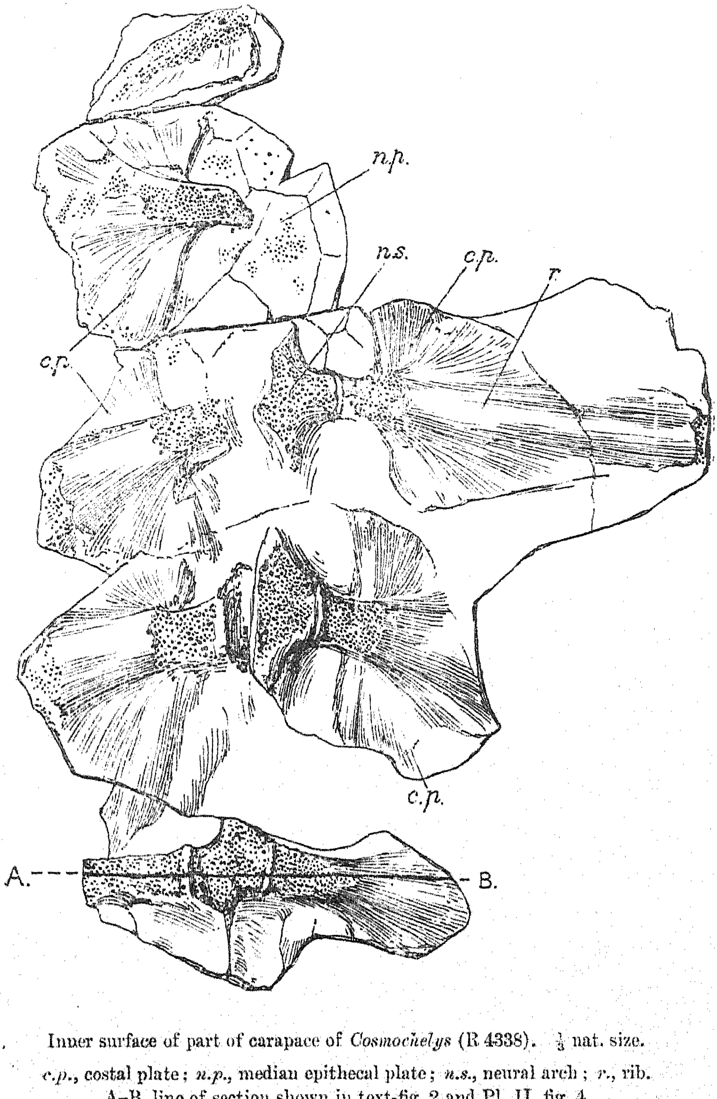
In the figure (Pl. II. fig. 4, text-fig. 2) the relations of the costals, neurals, ribs, and neural arches to one another and to the epithecal shell is well shown. It will be noticed that the median ridge of the epithecal shell is not immediately above the middle line of the underlying neural, but in the crushing that has been undergone has been displaced to one side. This probably indicates that in life the epithecal and vestigial thecal shells were separated by a considerable layer of soft tissue now represented by a thin film of matrix only.

Of the remainder of the skeleton nothing is yet known. It is greatly to be desired that engineers and others who are on the spot where excavations are opened, would collect all the fragments that are exposed, especially in tropical localities like Nigeria, where fossils once uncovered are rapidly disintegrated and cuttings very soon overgrown and rendered inaccessible. Of course, it would be still better if, when such works are in progress, a skilled collector could be present to see that nothing was lost.

The Chelonian above described approaches most nearly to *Psephophorus*, but, as pointed out, differs from this in several respects, notably in the arrangement of the plates on the epithecal shell, and it is therefore referred to as a new genus *Cosmochelys*, the specific name being *Cosmochelys dolloi* in honour of Professor L. Dollo, who has done so much to elucidate the history of this group of Chelonians.

This specimen is of especial interest, because it appears to help

Text-figure 3.



Inner surface of part of carapace of *Cosmochelys* (R 4338). ⅓ nat. size.
c.p., costal plate; *n.p.*, median epithecal plate; *n.s.*, neural arch; *r.*, rib.
A–B, line of section shown in text-fig. 2 and Pl. II. fig. 4.

to fill up one of the gaps in the series of forms which end in *Dermochelys*. According to Dollo's[*] view, the Cheloniidæ and related forms, which no doubt were derived from littoral and, more remotely, from terrestrial types, underwent a reduction of their thecal armour in consequence of their becoming more and more adapted to pelagic life; this reduction seems to have culminated in the later Cretaceous, in such forms as *Allopleuron*, *Protostega*, *Archelon*. Dollo then supposes that some such pelagic form re-adopted a littoral or perhaps a swamp life and that these new conditions rendered a protective armour again necessary. This was not formed by a re-development of the thecal skeleton, but by the formation of an epithecal armour external to it. Whether, as Dollo seems to believe, this was an entirely new formation or resulted from the increased development of epithecal elements already present, as Völker, Hay, and others think, is not certain. The presence of epithecal elements in the neural and probably in the supramarginal regions of the shell of *Archelon* gives some support to the latter view, especially as it is generally agreed that the marginals of all Chelonians are of epithecal origin. However this may be, it appears that in forms like that now described a very strong epithecal skeleton with a strongly sculptured outer surface was developed outside the reduced thecal shell, and this could only have been of use to a littoral or even partly terrestrial animal. This stage in the series should theoretically occur in the early Tertiary period, and it is precisely from this horizon (Lower or Middle Eocene) that *Cosmochelys* comes. It is supposed that subsequently this or some similar form returned to a pelagic mode of life, which in turn resulted in the reduction of the epithecal skeleton. In the Oligocene-Miocene genus *Psephophorus*, this has not advanced very far, and is chiefly manifested in the multiplication of the number of plates between the ridges and in the less strongly developed sculpture of the surface. In the culminating form, *Dermochelys*, the reduction has advanced so far that the plates of the carapace are very thin, smooth, and very numerous between the ridges: in the plastron they have almost entirely disappeared. Unfortunately, in *Cosmochelys* nothing is known of the plastron, either thecal or epithecal, but probably the epithecal was well developed.

The discovery of further remains of this interesting Chelonian will be awaited with great interest.

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[*] Dollo, "Première Note sur les Chéloniens oligocènes et néogènes de la Belgique," Bull. Mus. roy. d'Hist. Nat. de Belgique, tom. 5 (1888), p. 59. Also "Sur l'Origine de la Tortue Luth (*Dermochelys coriacea*)," Bull. Soc. roy. des Sciences médicales et naturelles, 1901. Also "*Eochelone brabantica* . . . . et l'Evolution des Chéloniens marins," Bull. Acad. roy. des Belgique, 1903, p. 792, and other papers.

Lists of papers relating to the origin of the Athecæ are given by Versluys, Report Brit. Assoc. 1913 (Birmingham), p. 806; and by Völker, on "Ueber das Stamm, Gliedmassen-, und Hautskelet von *Dermochelys coriacea*," Zoologische Jahrbücher (Anatomie), vol. xxxiii. (1912–13), p. 543.

EXPLANATION OF THE PLATES.

Plate I.

Pappocetus lugardi, gen. et sp. nov.

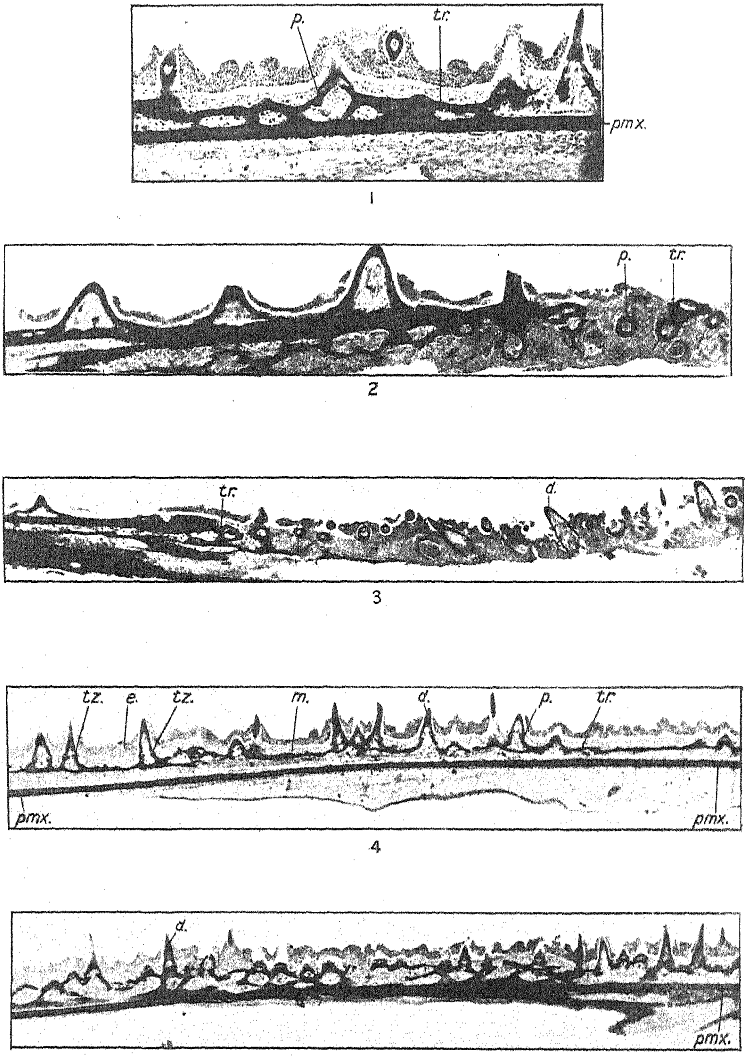
Fig. 1. Mandible, outer side. (Type-specimen M 11414.) ⅓ nat. size.
2, 2*a*. Outer and inner aspects of first molar of specimen M 11086. ⅔ nat. size.
3. ? Incisor (M 11087). Nat. size.
4. Anterior face of imperfect axis vertebra (M 11089). ½ nat. size.

Plate II.

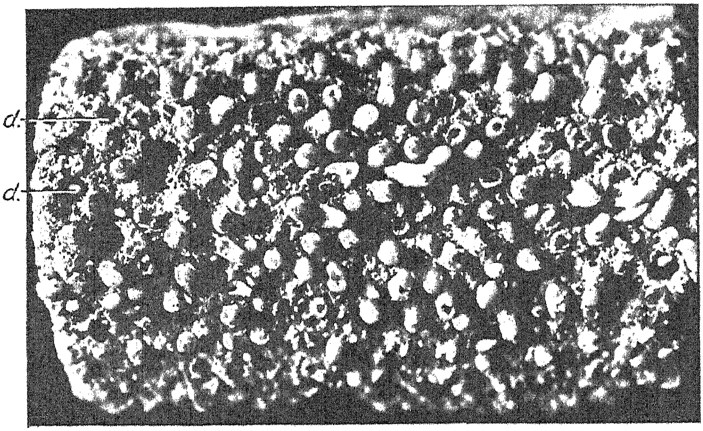
Cosmochelys dolloi, gen. et sp. nov. (Type-specimen R 4338.)

Fig. 1. Outer surface of middle portion of epithecal shell. ⅔ nat. size.
2. Outer face of intermediate plates of epithecal shell. Nat. size.
3. Outer face of two lateral plates of epithecal shell. ⅔ nat. size.
4. Vertical transverse section through thecal and epithecal shell. Nat. size.

c.p., costal plate.
c.r., central ridge.
ep., epithecal shell.
l.r., lateral ridge.
n., neural plate.
n.sp., neural spine.
r., rib.



XIPHIAS GLADIUS.



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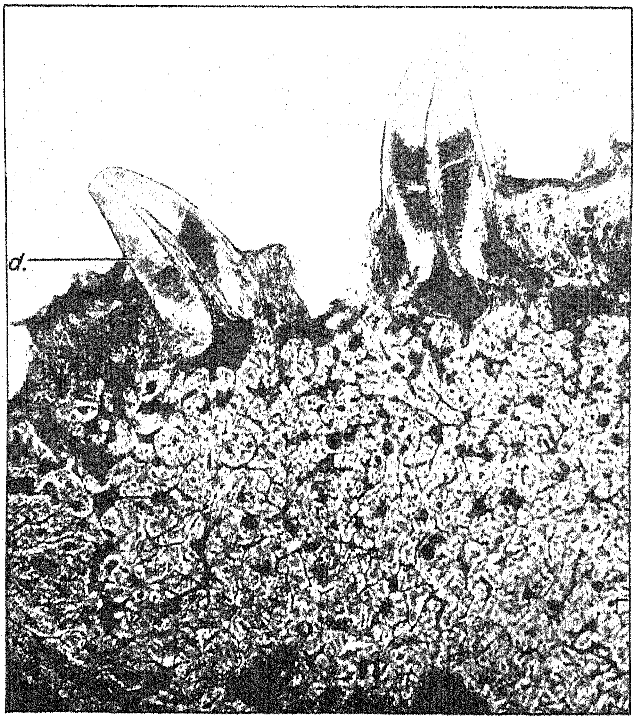
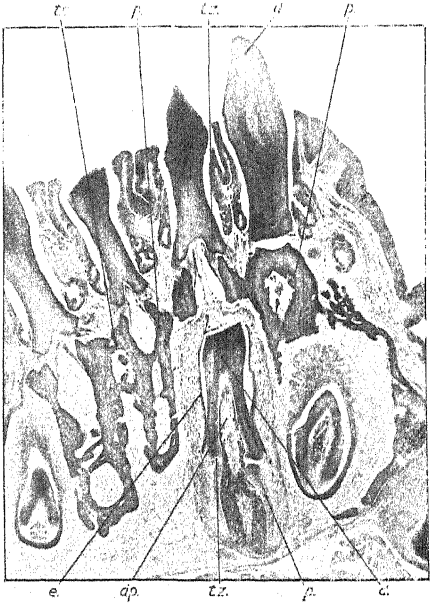


2

HISTIOPHORUS.



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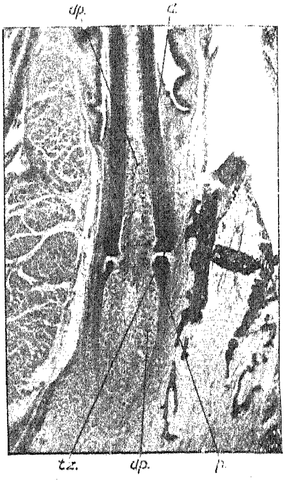

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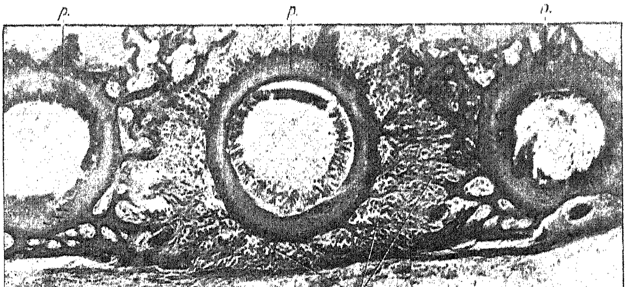

3

1. BLENNIUS. 2 & 3. PAGELLUS.

19. On the Occurrence of Denticles on the Snout of *Xiphias gladius*.

By J. THORNTON CARTER (Hon. Research Assistant, Department of Zoology, University of London, University College).

[Received June 16, 1919: Read June 17, 1919.]

(Plates I.–III.*)

The purpose of this communication is to describe the appearances seen in the examination of a portion of the rostrum of a young *Xiphias gladius* which was kindly given by Dr. Smith Woodward, F.R.S., to Professor J. P. Hill, F.R.S., who handed it to me for report, since I am engaged, under his direction, in an investigation of the histogenesis of dental tissues.

Sections of the material disclose the presence of denticles, hitherto described amongst Teleosteans only in various Siluroid fishes.

These little conical denticles (Pl. I. fig. 4, *d*) are seen to rest on pediments (*p*) to which they are attached by a substance having a translucent appearance (*tz*), and this area of attachment invariably coincides with the point of contact of epithelium (*e*) and the underlying connective tissues (*m*). These pediments are connected with their neighbours by trabeculæ (Pl. I. fig. 4, *tr*), and so a continuous bony layer is formed overlying the premaxilla (Pl. I. fig. 4, *pm*), with which however it enters, at certain places, into a connection so intimate that no line of demarcation is visible (Pl. I. fig. 1). Where the section passes transversely through the base of such a pediment it is seen to have an annular shape (Pl. I. fig. 2, *p*) the lumen of which is occupied by a continuation of the dental papilla.

The denticles develop (Pl. I. fig. 3) as is usual, from a mesoblastic papilla which is invested by an ingrowth of the deeper layer of the oral epithelium to form an enamel organ consisting of a double layer of cells, the innermost of which is made up of columnar cells, the ameloblasts, whilst the outer layer or external epithelium consists of cuboidal cells.

I have not been able to procure a portion of the rostrum of an adult *Xiphias* for comparison with my sections of the young, but Mr. Tate Regan, F.R.S., has kindly given to me a piece of the rostrum from a skeleton of an adult *Histiophorus* and also a fragment of the skin taken from the area of junction of the rostrum with the rest of the skull. This portion of skin contains, lying in its substance, the small tips of denticles, which would seem to show that they are developed in the same manner as those seen in the sections of *Xiphias*.

But, as the rostrum elongates, a change occurs in the site of development, for now the forming denticles are seen to lie in crypts at the sides of the bases of denticles already erupted and attached (Pl. II. fig. 1, *d*).

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* For explanation of the Plates see p. 325.

As these successional denticles grow their predecessors become detached and shed, their removal being brought about by absorption at the base. In sections of the rostrum there is no trace of the superficial denticles, which consist of typical fine-tubed dentine (Pl. II. fig. 2, *d*) becoming embedded in the substance of the bone. The denticles are larger along the lateral margins than on the upper and lower surfaces.

The presence of denticles in any Teleostean fish is a point of interest, for the question arises "What part do the denticles play in the development of the bony layer to which they are attached"? Goodrich (Proc. Zool. Soc. 1907, pp. 763–764) states:—"Nor is there any evidence that denticles do ever really contribute to form dermal bones. Even in the case of the palatal bones of fish and amphibians, the teeth do not actually combine to build up the supporting bone, but become fused sooner or later to bony substance *independently* developed at their base" (the italics are mine).

On this important point I am unable to agree with Goodrich for reasons advanced later in this paper.

Denticles develop in the soft tissues and usually are supposed to obtain a secondary attachment to the bone, but I am not aware of any detailed account of how such attachment takes place. In the absence of fixed material of older Swordfishes I have had to turn to other fishes to trace out the development of the denticle and its pediment and how attachment between them is effected. I realize the objection can be raised that the conditions obtaining in the case of teeth in the mouth may be adaptations to special conditions, but the manner of development of denticles in *Xiphias* and *Histiophorus*, and their mode of attachment, appears to be identical with that of teeth in the various areas of the mouth in other Teleosts.

As in the case of the denticle of *Xiphias*, the point of attachment of the tooth to its pediment is always at the point of junction of epithelium with mesoderm. Whether development takes place in a bony crypt or deep in the soft tissues, far from the surface, it is invariably found that the epithelial inflection, the enamel organ, extends down the whole length of the tooth to the transparent area, where it ends.

In Pl. III. fig. 1, which is a photomicrograph of a section through the pharyngeal plate of a Blenny, a developing tooth is shown lying beneath the functional teeth. It is seen to consist of a tooth (*d*), a translucent zone (*tz*), and a pediment (*p*), all forming on the surface of one papilla (*d.p*). The epithelium (*e*) is seen to extend down to the limits of the tooth.

On examining the functional teeth it is apparent that the relationship between the various parts still exists: the teeth are still connected, by means of the translucent area (*tz*), to the pediments but now these latter are joined one to another by trabeculæ of bone (*tr*). When the teeth first erupt they are slightly movable and easily detached, breaking away at the point of junction of tooth and pediment, but rapidly they become so firmly anchylosed that considerable force is required to detach a tooth. The line of fracture, however, is still the same.

In Pl. III. fig. 2, a developing tooth of a Sea-Bream is shown in which the relationship of the various parts is seen to be similar to that described in the Blenny. The continuity of the cells on the surface of the dentinal papilla (*d.p*) is well shown. I have followed out a complete cytomorphosis of these cells in several Teleostean fishes and find that the changes through which they pass are identical whether they go to form the denticle, the pediment, or the connecting area.

Pl. III. fig. 3, exhibits a transverse section through the pediment of a recently erupted jaw-tooth of a Sea-Bream. It is seen that trabeculæ (*tr*) pass outward from the surface of the pediment (*p*) and, traversing the connective tissues, blend with those of adjoining teeth already fixed in place. These trabeculæ are at first thin, flexible, and transparent, but rapidly thicken until eventually a section through this area presents the appearance of an almost solid plate of bone.

Once firm attachment is effected the pediment in its growth downwards no longer retains its annular form but divides into separate trabeculæ, the bone cells on the outer surface being continuous with and indistinguishable from those on the inner surface and derived from the dental papilla. The pulp chamber of the erupted tooth becomes almost completely obliterated, the typical dentinal structure being maintained, whilst coarse trabeculæ grow inwards and fill the lumen of the pediment.

Briefly put, the tooth with its pediment develops deep in the tissues as a single entity, and not until it has assumed its functional position does its pediment enter into connection with those of adjacent teeth to form a continuous supporting plate; the tooth invariably retains its characteristic dentinal structure but the pediment in its growth undergoes a gradual and progressive transition, both on its outer and inner surface, from dentine to bone and becomes incorporated in the substance of the bone.

The translucent zone (*tz*) constituting the junction of tooth and pediment, though formed before the eruption of the tooth, calcifies latest and usually appears to have a glassy structure.

The mode of development described above for the teeth holds good for the denticles in the young *Xiphias*, for though the soft tissues are somewhat macerated, my material being from a specimen preserved in spirit, yet the developing denticles which have not yet entered into any connection with the bone are found to consist of a cap of dentine and a pediment, connected by a transparent area, and, later, trabeculæ may be seen forming to join adjacent pediments. These pediments are seen to stand up above the level of the surrounding bone, but this bone continues to thicken and grow until its surface lies almost at the level of the transparent areas.

The denticles in the adult *Histiophorus*, developing as they do in the substance of the bone, may be said to have become teeth, and the appearances seen in sections from the rostrum conform with the observations described in the Blenny and the Bream.

Mr. Tate Regan has most generously given to me the post-temporal bone of one of the Loricariidæ, an adult *Pseudacanthus seriatus*, the examination of which confirms the account I have given as to the mode of development and attachment of the denticles and their part in the formation of the bone.

The surface of the bone is studded with denticles, some fully erupted and so firmly attached as not to become displaced in the preparation of ground sections of the whole bone, others but partly erupted and freely movable in their sockets which are widely open like the denticles in the rostrum of *Histiophorus* (Pl. II fig. 1, *d*). Where denticles have become detached the surface presents an appearance of circular areas with slightly raised edges, connected one with another by radiating trabeculæ and, but for the soft tissues being completely removed, affording a picture identical with that seen in Pl. III. fig. 3.

A ground section reveals the denticle, composed of hard tubed dentine with a tip of enamel, resting on a pediment which on its outer surface merges into the surrounding bone, whilst towards the pulp chamber the structure resembles coarse dentine; the denticle is continued downwards a little way into the cavity of the pediment, or in other words, is slightly socketed. In the anchylosed denticles attachment to the pediment is effected by a layer of almost structureless calcified tissue which occupies the area of junction.

The condition is identical with that seen in certain of the Gadidæ where the tooth, the pediment, and the connecting substance develop on the surface of the one dentinal papilla in the manner described earlier in this paper. At first the line of termination of the base of the tooth is straight as in Pl. III. fig. 1, but gradually the inner surface of the connecting transparent zone becomes converted into dentine to form the little downward extension seen in sections. Eventually, in certain areas of the mouth, the remainder of the connecting zone calcifies and the tooth is firmly anchylosed into place.

It is interesting to compare this description with that given by Williamson (Phil. Trans. 1851, Part II. p. 659) of the scale of *Loricaria cataphracta*. He wrote:—

"On the surface of the scale there are numerous small circular cavities which communicate inferiorly with branches from the network of Haversian canals. Each cavity is surrounded by a narrow projecting rim, upon which the flanging shoulders of the tooth rest, whilst its constricted base is fitted into the enclosed hole, thus producing an arrangement which closely resembles a ball-and-socket joint, and which must allow of a considerable degree of motion in every direction. The tooth is apparently held in its place by a capsular expansion of the membrane which covers the surface of the scale . . . . . . It only requires the tooth to be fixed instead of movable, and depressed instead of acuminate, in order to render it the exact homologue of one of the areolæ in the cosmine of *Megalichthys*."

Since tooth or denticle, pediment, and connecting area are formed on the surface of the same papilla, it seems certain that the difference of structure seen in the fully developed hard tissue is due to some influence exercised by the investing tissues. Over the area invested by epithelium the typical dentinal structure obtains; where the investment is mesodermal there is an approximation to bone, whilst at the point of junction of epithelium with mesoderm a layer is formed which, when calcified, presents a glassy appearance.

Though I have advanced evidence to show that the bone to which the teeth or denticles are attached is not independently developed, but is "an extension of the denticle cone," so that the sharp line of demarcation drawn by Goodrich between the tooth-bearing bones in Teleostei and the bases of Placoid scales does not exist, yet I have refrained, purposely, from discussing the very interesting theoretical problems which arise from a comparison of the conditions described in this paper with those existing in other orders of fishes. Until we possess a satisfactory account of the process of histogenesis of bone and dentine in fishes, based on properly fixed material, we cannot answer certain essential questions. Only the possession of fresh facts can advance our knowledge beyond the position so admirably presented in the classical papers of Williamson and of Goodrich.

My cordial thanks are due to Mr. F. J. Pittock, of the Zoological Department of University College, for the photographs used to illustrate this communication.

EXPLANATION OF THE PLATES.

The letters used have the following significance:—

d, denticle.
d.p, dentinal papilla.
e, epithelium.
m, mesoderm.
p, pediment.
pmx, premaxilla.
tr, trabeculæ.
tz, translucent zone.

PLATE I.

Fig. 1. *Xiphias gladius.* The bone developed by the junction of trabeculæ (*tr*) connecting the pediments (*p*) is seen blending with the surface of the premaxilla (*pmx*). ×90.

Fig. 2. The same. The circular pediments (*p*) are seen connected one with another by means of trabeculæ (*tr*) which also attach them to the neighbouring bone. × 40.

Fig. 3. The same. On the right-hand side of the figure denticles (*d*) are seen developing in the soft tissues; denticle (*d*) and pediment (*p*) are seen connecting by a translucent zone (*tz*). × 40.

Fig. 4. The same. A number of denticles (*d*) are seen resting on their pediments (*p*). The connecting translucent zone (*tz*) is seen to correspond with the junction of epithelium (*e*) with mesoderm (*m*). The continuous scaffolding of bone which supports the denticles is not connected at any point in the section with the premaxilla. × 40.

Fig. 5. The same. A section showing the relationship of the premaxilla to the secondary bone. × 40.

Plate II.

Fig. 1. *Histiophorus.* Photograph of the surface of the rostrum showing developing denticles (*d*) lying in widely open crypts. The erupted teeth are anchylosed in place. × 7·5.

Fig. 2. The same. Photomicrograph of a portion of a section of the rostrum showing two denticles (*d*) attached to the surface of the rostrum. × 40.

Plate III.

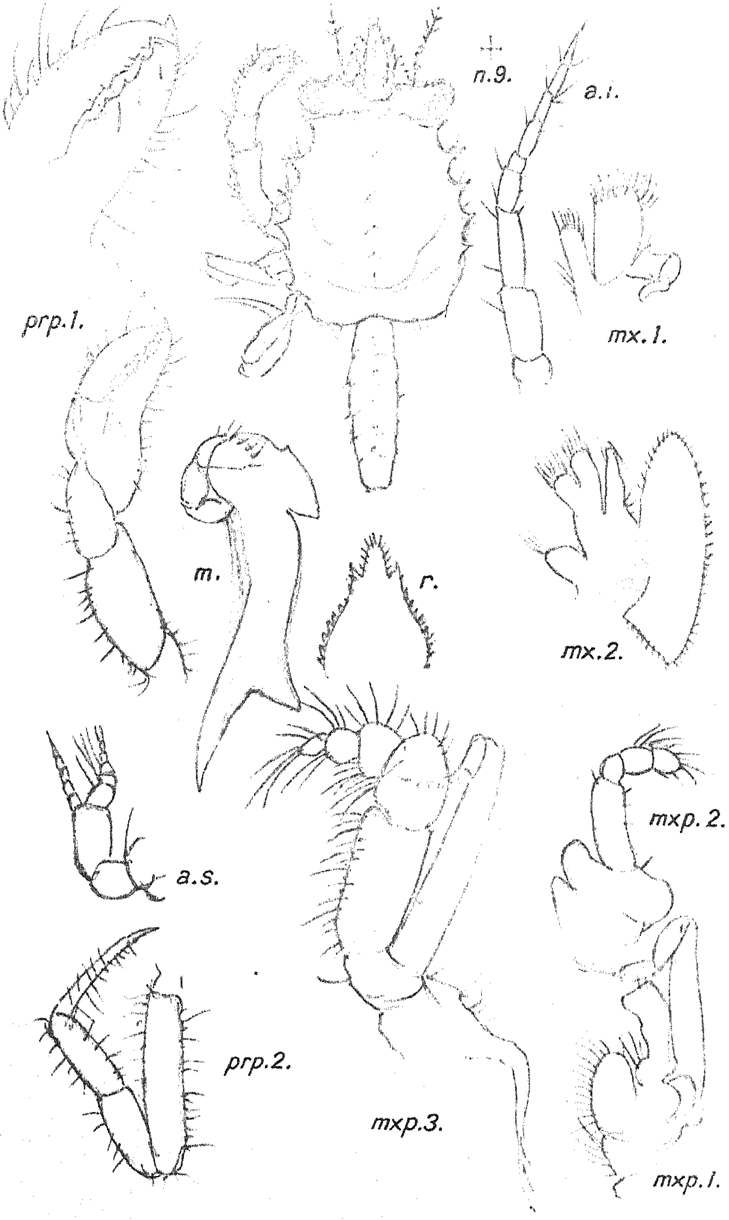
Fig. 1. *Blennius.* Photomicrograph of a section of the pharyngeal plate showing a developing tooth (*d*), its pediment (*p*), and connecting substance (*tz*). The epithelium (*e*) extends down to the limits of the tooth.

The pediments of the erupted teeth are joined one to another by means of trabeculæ of bone (*tr*). × 40.

Fig. 2. *Pagellus centrodontus.* Photomicrograph of a developing tooth showing the continuity of the cells of the dentinal papilla (*d.p*). × 90.

Fig. 3. The same. Photomicrograph of a transverse section through the bone underlying the teeth, showing the pediment (*p*) of a newly erupted tooth becoming attached to its neighbours by trabeculæ (*tr*). × 45.

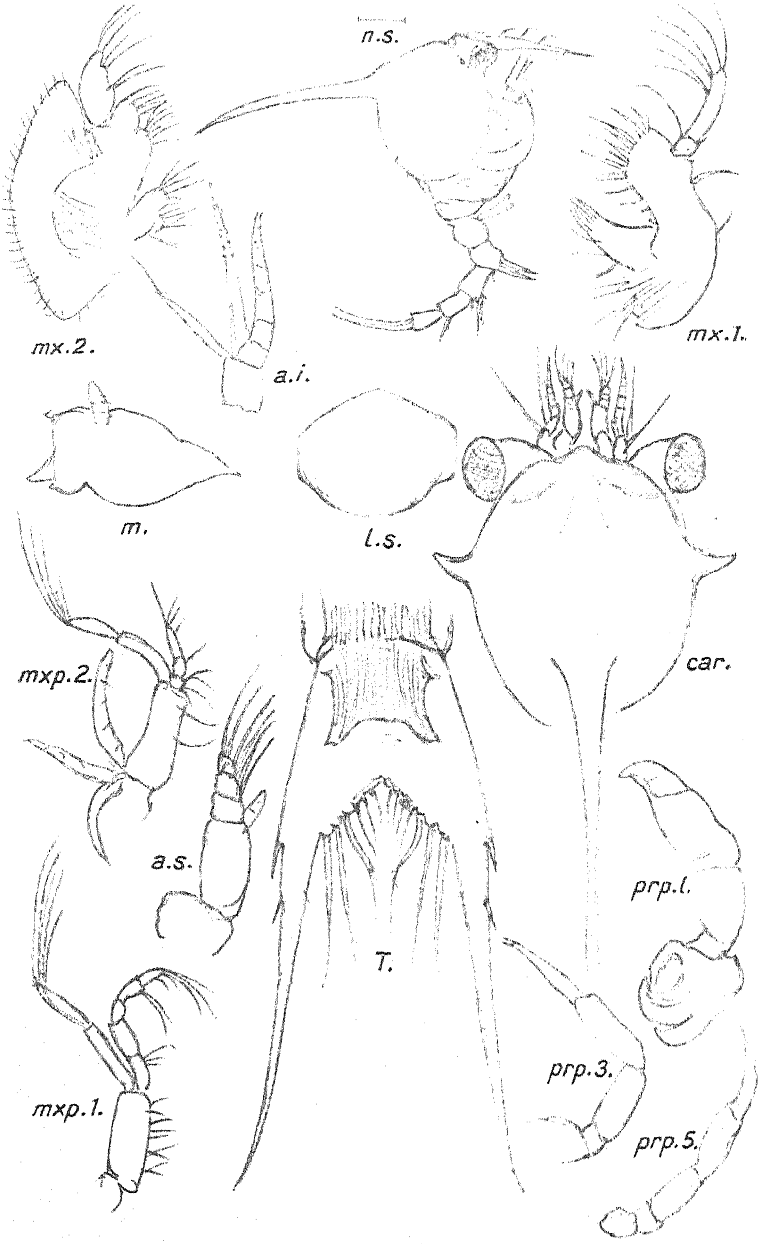
P. Z. S. 1919, STEBBING, Pl. I.



Del., T. R. R. Stebbing.

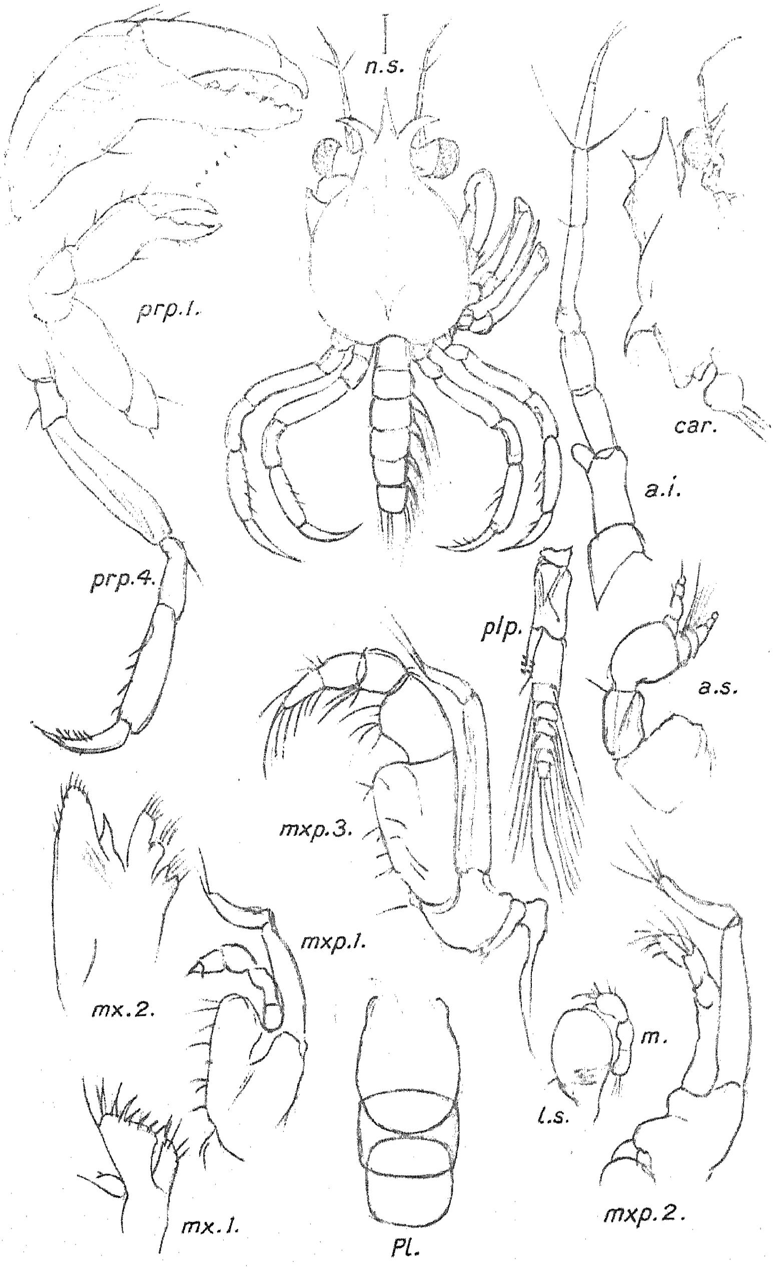
PELTARION SPINOSULUS (White) juv.

P. Z. S. 1919, STEBBING, Pl. II.



Del., T. R. R. Stebbing.

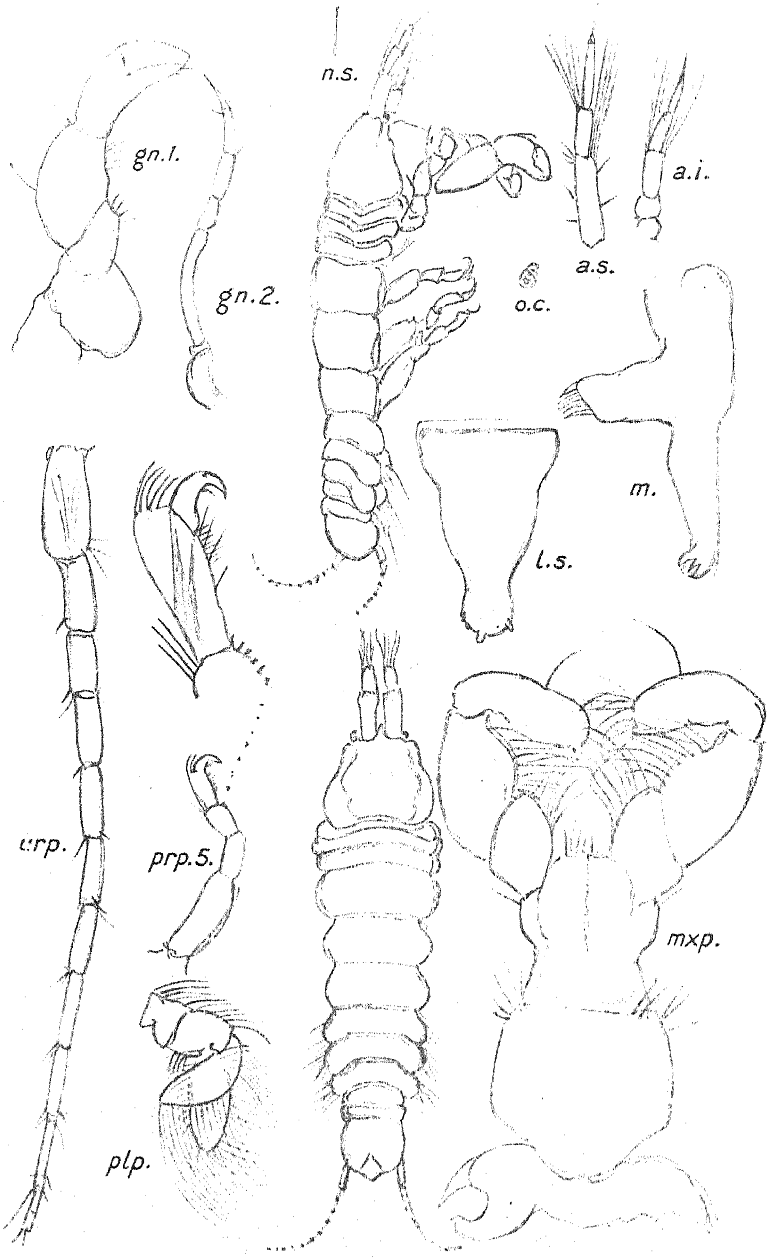
ZOEA of a BRACHYURAN.



Del. T. R. R. Stebbing.

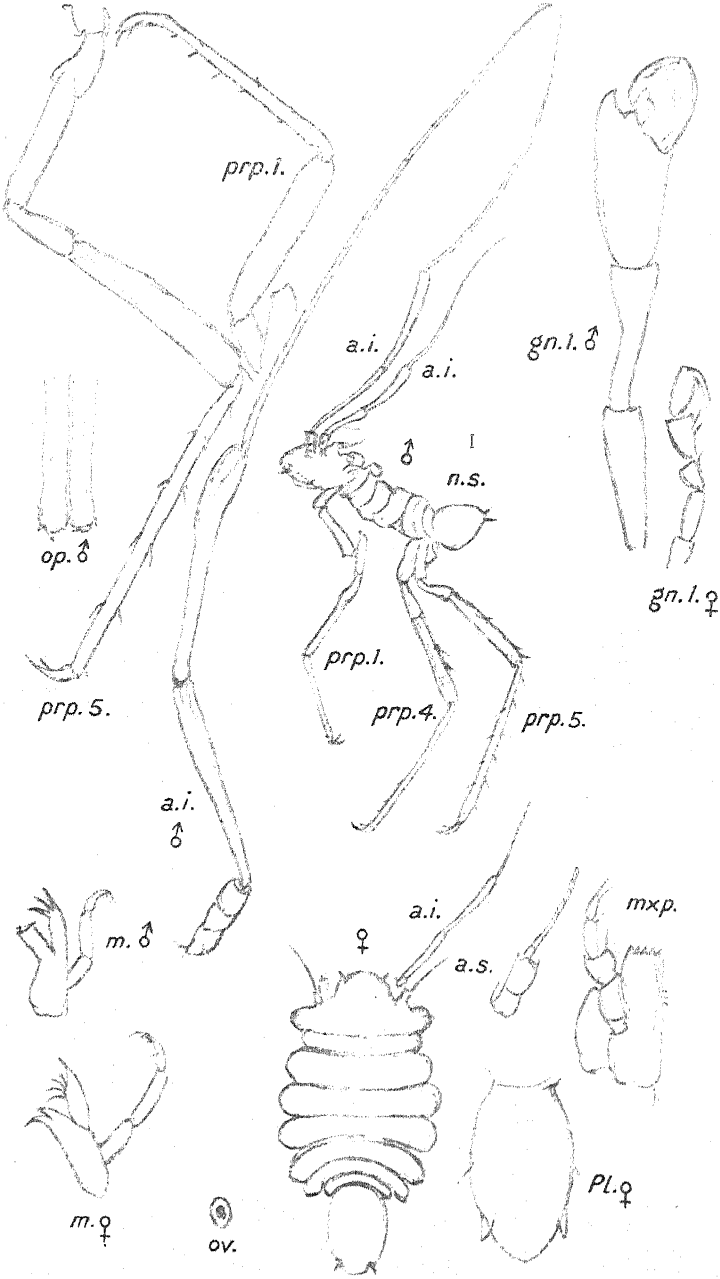
MEGALOPA of an OXYRRHYNCH.

P. Z. S. 1919, STEBBING, Pl. IV.



Del., T. R. R. Stebbing.

TANAIS NIERSTRASZI, n. sp.



Del., T. R. R. Stebbing.

MUNNA ANTARCTICUS (Pfeffer).

20. Crustacea from the Falkland Islands collected by Mr. Rupert Vallentin, F.L.S.—Part III. By the Rev. THOMAS R. R. STEBBING, M.A., F.R.S., F.L.S., F.Z.S.

[Received June 13, 1919: Read June 17, 1919.]

(Plates I.–V.* and Text-figures 1–8.)

In re-examining Mr. Vallentin's Malacostraca I have observed some forms, chiefly specimens of very small size, which seem worthy of notice in this concluding report.

Brachyura.

Tribe CYCLOMETOPA.

Family ATELECYCLIDÆ.

Genus *Peltarion* Jacquinot.

Peltarion spinosulus (White) juv.

Family PORTUNIDÆ.

Larval genus *Zoea* Bosc.

Tribe OXYRRHYNCHA.

Larval genus *Megalopa* Leach.

Macrura Anomala.

Tribe GALATHEIDEA.

Family GALATHEIDÆ.

Genus *Munida* Leach.

Munida gregarius (Fabricius).

Schizopoda.

Tribe THYSANOPODACEA.

Family THYSANOPODIDÆ.

Genus *Nematoscelis* Sars.

Nematoscelis rostratus Sars.
(*Cyrtopia* stage.)

Isopoda Anomala. (or Apseudacea).

Family TANAIDÆ.

Genus *Tanais* Audouin & M. Edwards.

Tanais nierstraszi, sp. n.

Isopoda Genuina.

Tribe FLABELLIFERA.

Family ÆGIDÆ.

Genus *Æga* Leach.

Æga semicarinatus Miers.

Family SPHÆROMIDÆ.

Genus *Dynamenella* Hansen.

Dynamenella eatoni (Miers).

Tribe ASELLOTA.

Family MUNNIDÆ.

Genus *Munna* Kröyer.

Munna antarcticus (Pfeffer).

Amphipoda.

Family LYSIANASSIDÆ.

Genus *Tryphosites* Sars.

Tryphosites chevreuxi Stebbing.

Family METOPIDÆ.

Genus *Metopoides* Della Valle.

Metopoides parallelocheir (Stebbing).

Family PONTOGENEIIDÆ.

Genus *Paramœra* Miers.

Paramœra austrinus (Bate).

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* For explanation of the Plates see p. 339.

MALACOSTRACA.

BRACHYURA.

Tribe CYCLOMETOPA.

Family ATELECYCLIDÆ.

Genus PELTARION Jacquinot.

The systematic position of this genus and its nomenclature have been already discussed in Proc. Zool. Soc. for 1900, pp. 518–519, where also bibliographical details are supplied for the following species.

PELTARION SPINOSULUS (White) juv. (Pl. I.)

Writing as to his collecting of Crustacea between November 1901 and March 1902 Mr. Vallentin says:—"I have dredged one specimen of this species in Stanley Harbour in 3 fms. in the black mud. It is common in certain protected bays fringing the ocean, being easily procured during low-water spring tides. Its presence can at once be detected by a slight blister in the sand. About an inch deep in the sand under one of these mounds a crab can always be secured. Gulls, *Larus dominicanus*, are splendid fellows at finding these crabs. With one dig with their bill and a twist they turn them out from their hiding places, and directly tear them in pieces and devour them."

Though the adult form of the species has long been well known, I have not been able to find any description of the juvenile stages, one of which seems to me to be represented by the minute specimen which I have figured.

The carapace measures about 3 mm. in length by 2 mm. in breadth, while the adult may have a breadth of 50 mm. and a length somewhat greater. The eyes of the small specimen are in the Megalopa stage, and the five spinulose teeth on each side of the carapace to the rear of the eyes and the spinulose eminences along its medio-dorsal line must undergo considerable modification in the later development. On the other hand, the microscopically denticulate rostrum and many other details are strongly in favour of the proposed identification. Many points of agreement may be observed by comparing the account which Miers gives of the genus ('Challenger' Reports, vol. xvii. p. 210, 1886) with various details here figured. Attention may be called to the third maxillipeds; to the chelipeds (prp. 1) with the "fingers robust, scarcely as long as the palm, and rather obscurely dentated on the inner margins, distally acute; the dactylus spinuliferous on the superior margin," as described by Miers for the adult male, and here only differing by the greater length of the fingers in relation to the palm, the other peræopods also agreeing with Miers's description, "dactyli styliform, slender, and much longer than the penultimate joints."

Family PORTUNIDÆ.

Larval Genus ZOEA Bosc. (Pl. II.)

1769. *Monoculus* Slabber, Natuurkundige Verlustigingen, part 5, p. 35, pl. 5. figs. 1, 2.
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1813. *Zöe* Leach, Edinb. Encycl. vol. vii. p. 389.
1818. *Zoëa* Leach, in Tuckey's River Zaire Exp., Appendix 4, p. 414.
1830. *Zoea* Thompson, Zoological Researches, vol. i. [Milne Edwards].
1837. ,, Milne Edwards, Hist. Nat. Crust. vol. ii. pp. 431–438.
1878. *Zoëa* Claus, Untersuch. des Crustaceen-Systems, pp. 1, 31, 63, etc.
1903 ,, Williamson, Fishery Board Scotland, Rep. xix. pt. 3, p. 136.
1911. ,, Williamson, Fisheries, Scotland, Sci. Invest. 1901, No. 1.
1918. *Zoea* Meek & O. Jorgensen, Rep. Dove Marine Lab. pp. 23, 62.

Slabber's description and figure of his *Monoculus taurus* seem to give him priority in the observation of this form of crustacean life. By his laudable anxiety not needlessly to increase the number of genera he has lost the credit, such as it is, of giving it its first generic title. Yet he recognised the absurdity of including in the definition of *Monoculus* "oculi duo," whether expressed or implied in the plural "oculi approximati." It may be noticed that Leach gives a very uninstructive figure of his *Zoëa clavata*. The account by Milne Edwards of fluctuating opinion down to 1837 is of great interest, as is that by Claus later on. Professor Meek proposes that the term *Zoea* should be limited to the larvæ which have "more than eight but not more than thirteen pairs of appendages." The specimen which I have figured from the Falklands shows much likeness to that represented by Claus (loc. cit. pl. xi.) as the *Zoea* of some member of the family Portunidæ.

Tribe OXYRRHYNCHA.

Larval Genus MEGALOPA Leach. (Pl. III.)

1813. *Megalopa* Leach, Edinb. Encycl. vol. vii. pp. 394, 431.
1816. ,, ,, Encycl. Brit., Suppl., Ed. 5, p. 417.
1818. ,, ,, in Tuckey's River Zaire Exp., Appendix 4, p. 414.
1825. ,, Desmarest, Consid. gén. Crust. p. 200.
1837. *Megalops* Milne Edwards, Hist. Nat. Crust. vol. ii. p. 260.
1874. ,, S. I. Smith, Invert. Vineyard Sound, p. 237 (531), pl. 8. fig. 38.

1876. *Megalopa* Claus, Untersuch. des Crustaceen-Systems, pp. 66 etc.
1911. *Megalops* Williamson, Fisheries, Scotland, Sci. Invest. 1909, pp. 4, 8, 11, 13, 15.
1918. *Megalopa* Meek, Rep. Dove Marine Lab. p. 30.
1918. *Megalops* Olga Jorgensen, Rep. Dove Marine Lab. p. 61.

Various other references will be found indicated in the works above cited. In 1769 or 1770 Slabber, in his 'Natuurkundige Verlustigingen,' Part 18, p. 159, pl. 18. fig. 1, describes and figures "an oblong-quadrate sea-crab," the size of a grain of wheat, which is no doubt a *Megalopa*, but Slabber supplies no Latin name. In 1783 Herbst in allusion to its size named it *Cancer granarius* (Naturg. Krabben und Krebse, Parts 2-5. p. 107, pl. 2. figs. 28 *a*, A.). His reproduction of Slabber's figure is not specially accurate. Later on, in the third volume of O. F. Müller's 'Zoologia Danica,' edited by Abildgaard (p. 56, pl. 114. figs. 1-3; 1789) appears *Cancer faeroensis*, also with a tridentate front, and recognised by Milne Edwards (loc. cit. p. 262) as a *Megalopa*. In 1804 Montagu described and figured his *Cancer rhomboidalis* (Tr. Linn. Soc. vol. vii. p. 65, pl. 6. fig. 1), a species apparently belonging to the Cyclometopa, and on this Leach in 1813 founded his genus *Megalopa*, renaming Montagu's species as *Megalopa montagui* (Malac. Pod. Brit. pt. 14, pl. 16. figs. 1-6; 1817).

The *Megalopa* of *Cancer irroratus* Say has been carefully ascertained by S. I. Smith, and as the adult is clearly allied with *Cancer pagurus*, presumably the *Megalopa* stage will be nearly the same in the two species. The *Megalopa* of *Carcinus mænas* figured by Spence Bate is reproduced in Huxley's 'The Crayfish' (p. 282, figs. 74, C, D. ed. 3; 1881) by a slip under the name of *C. pagurus*. Williamson, who uses *Megalopa* as the plural of *Megalops*, supplies figures of this stage for *Portunus holsatus*, *Portunus puber*, and a species which he believes to be *Hyas araneus*. As our Falkland Island specimen shows good agreement with the last-named form it may reasonably be allotted along with it to the Oxyrhyncha, leaving open the question of its genus and species.

MACRURA ANOMALA.

Tribe GALATHEIDEA.

Family GALATHEIDÆ.

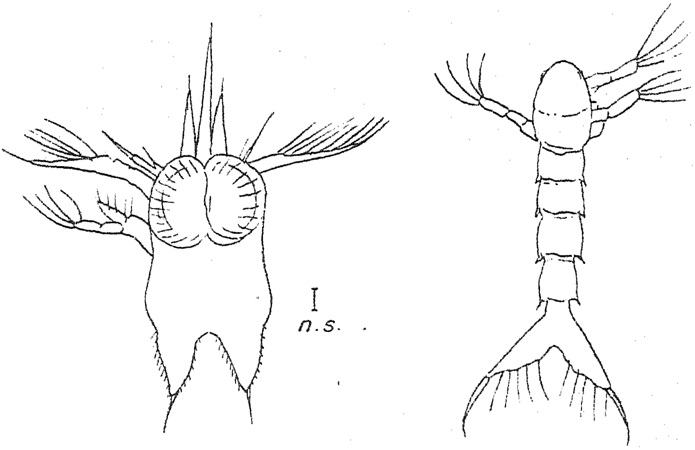
Genus MUNIDA Leach, 1820.

MUNIDA GREGARIUS (Fabricius), 1793.

The adult form has been already mentioned in these Proceedings for 1914, p. 346. The figures here given refer to a very early larval stage, in which the carapace has only a length of 2 mm. The generic identification may, I think, be relied on by a comparison with the description and figures which Professor G. O. Sars supplies for a similar stage of *Munida rugosus* (Fabricius) in his "Bidrag til Kundskaben om Decapodernes Forvandlinger," ii. p. 178, tab. 6 (Arch. Naturv., 1889).

The figures give a dorsal view of the specimen in two divisions, the line *n.s.* indicating the actual length of the carapace.

Text-figures 1 & 2.



Munida gregarius, early larval stage.

SCHIZOPODA.

Tribe THYSANOPODACEA.

Family THYSANOPODIDÆ.

For the classification see Ann. S. African Mus. vol. vi. pp. 395, 396 : 1910.

Genus NEMATOSCELIS G. O. Sars.

1883. *Nematoscelis* Sars, Vid. Selsk. Forhandl. Christian., No. 7, p. 27.

NEMATOSCELIS ROSTRATUS Sars.

1885. *Nematoscelis rostrata* Sars, Rep. Voy. 'Challenger,' vol. xiii. Schiz., pp. 135, 169, pl. 25. figs. 8–10, pl. 31. figs. 23–29.

Among numerous specimens of larval forms belonging to other groups there occurred a single slender form 4·5 mm. in length, having a telson in minute agreement with that figured by Sars for the *Cyrtopia* larva of his species above-named. His description of the telson says, "The middle projection of its extremity (fig. 29) is considerably produced, but narrowly truncate at the tip; and of the seven original spines, three only remain. Of the three outer spines, the innermost on either side is much larger than the others, and has assumed the character of the subapical spines." The outermost, as shown in the figure 29 is microscopic, and in the upper part of the telson but below the middle (not included in fig. 29) there is another microscopic pair. The carapace has a denticle on each side below the middle. The first legs in the Falkland specimen, however, have not attained the same relative length as that shown in fig. 25 of the 'Challenger' report. In various papers H. J. Hansen makes *N. rostratus* a synonym of *N. microps* Sars. On this I am not presuming to pass an opinion, but retain the name *rostratus* for the better identification of the Falkland Island specimen with the 'Challenger' *Cyrtopia* form.

ISOPODA ANOMALA.

(or Apseudacea).

Family TANAIDÆ.

See Proc. Zool. Soc. 1914, p. 348, and add for the present purpose:—

1884. *Tanaidæ* Studer, 'Gazelle' Isopoden, p. 24.
1886. ,, Beddard, Rep. Voy. 'Challenger,' vol. xvii. Part 48, p. 119.
1914. ,, Barnard, Ann. S. Afr. Mus. vol. x. pt. 11, p. 331 *a*.

Genus TANAIS Audouin & M. Edwards, 1829.

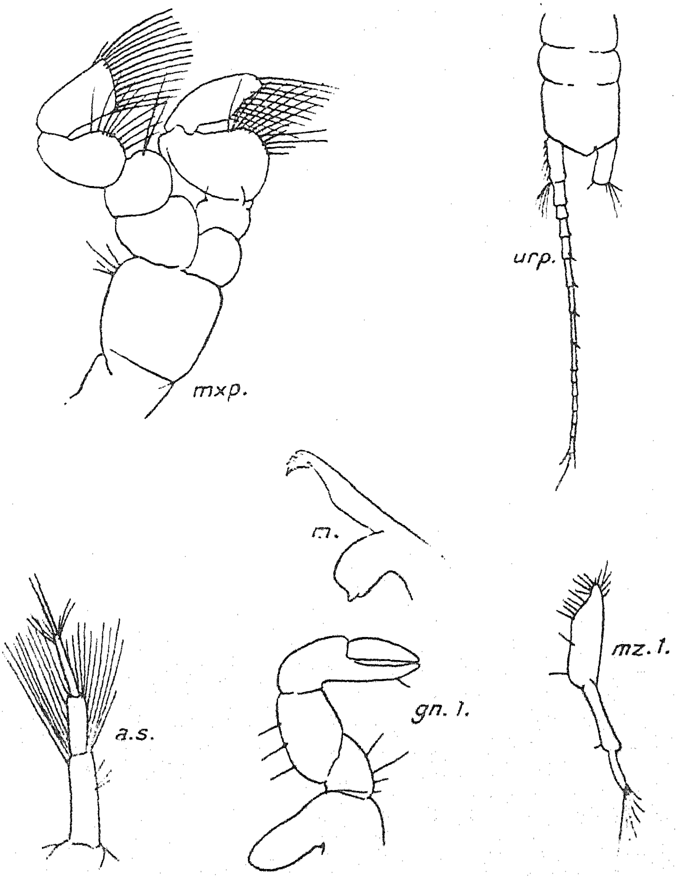
TANAIS NIERSTRASZI, sp. n. (Pl. IV.)

The present species belongs to that division of the genus in which the pleon has six segments. In having the last three abruptly narrowed it agrees with *T. normani* Richardson, differing from it by having the ramus of the uropods 10-jointed. In this respect it stands between the large blind *T. willemoesii* Studer, which has 8 joints, and *T. hirsutus* Beddard, which has, including peduncle, "about 12." From the latter, taken "off Prince Edward Island; depth 50 to 150 fathoms," it appears to be distinguished by the very different proportions of many of the body segments.

The eyes are dark, piriform, at the rounded angles of the cephalothorax, which has a broad front with short rostrum, and gradually attains a breadth at least equal to the length. The first antennæ are as in *T. hirsutus*, with crowded setæ on joints of the peduncle, but only a minute one-jointed flagellum tipped with long setæ.

The mandible ends in four crowded teeth or short setæ from which a narrow strip of the trunk leads to the strong molar.

Text-figures 3-8.



Tanais nierstraszi.

a.s. First antenna. *m.* Mandible. *mx.* 1. First maxilla. *mxp.* Maxillipeds. *gn.* 1. First gnathopod. *urp.* One of the uropods in attachment to part of pleon; the ramus should be 10-jointed.

The first maxilla has its oblique apical margin spinose, with a group of subapical setæ on the outer margin; the long two-jointed palp ends in several setæ. The maxillipeds have the apex of the palp's fourth joint, like the two preceding joints, provided with a crowd of setæ. The broad third joint is apically narrowed. The first gnathopod is normal, the fingers closing without a gap, and the apical teeth overlapping. The second gnathopods are very slender. In the fifth peræopods the penultimate joint has the lower half of its front margin fringed with small spines. The rami of the pleopods have very long fringes.

A specimen nearly 7 mm. in length was taken by Mr. Vallentin at Roy Cove from a depth of 3–4 fathoms. The smaller specimen, 5 mm. long, he took from the surface. To this the text-figures refer.

The specific name is given in recognition of Professor H. F. Nierstrasz's valued studies of the Isopoda.

ISOPODA GENUINA.

Tribe FLABELLIFERA.

Family ÆGIDÆ.

Genus ÆGA Leach, 1815.

ÆGA SEMICARINATUS Miers.

1875. *Æga semicarinata* Miers, Ann. Nat. Hist. ser. 4, vol. xvi. p. 115.
1877. ,, ,, Miers, Phil. Trans., Zool. Kerguelen, Crust., p. 2, pl. xi. fig. 1.
1891. ,, ,, Dollfus in Crust. Miss. Cap Horn (A. M.-Edw.) p. 57, pl. 8. figs. 2, 2 *a*.
1914. ,, *urotoma* Barnard, Ann. S. Afr. Mus. vol. x. p. 367, pl. 32 A.

In a manuscript note Mr. Barnard identifies his *urotoma* with the present species. His figure of the telsonic segment, however, does not show nor does his description mention the slight mediodorsal carina which is recorded and figured by Dollfus and is present in the Falkland specimen. This was found by Mr. Vallentin on drift *Macrocystis* near West Point Island. It measures 49 mm. in length, with a breadth rather over 21 mm. In the first antenna the flagellum is 10-jointed. The difference of fourteen joints in that of the Cape specimen cannot be considered important, as the total length of the Cape example was also larger, being 53 mm.

Our specimen has the whole dorsal surface of the pleon and the last side-plates of the peræon strongly pitted. In the first gnathopods the fourth and fifth joints are very short, the sixth has a minute process on the inner margin, and the seventh is strongly bent with the apex acute and black.

Family Sphæromidæ.

Genus Dynamenella Hansen.

1905. *Dynamenella* Hansen, Q. J. Microsc. Sci. vol. xlix. pp. 96, 107, 117, 125.
1905. ,, H. Richardson, Mon. Isop. N. Amer. p. x.
1906. ,, H. Richardson, Pr. U.S. Nat. Mus. vol. xxxi. p. 14.
1914. ,, Barnard, Ann. S. Afr. Mus. vol. x. p. 410.

Dynamenella eatoni (Miers).

1875. *Dynamene eatoni* Miers, Ann. Nat. Hist. ser. 4, vol. xvi. p. 73.
1891. ,, ,, Dollfus, Crust. Miss. Cap Horn, p. 66.
1905. *Dynamenella eatoni* Hansen, Q. J. Microsc. Sci. vol. xlix. p. 125.

Mr. Vallentin's specimens, taken on the shore at Stanley Harbour and from a depth of 3 to 4 fathoms in Roy Cove, were all females.

Tribe ASELLOTA.

Family Munnidæ.

1899. *Munnidæ* Sars, Crust. Norway, vol. ii. p. 105.
1916. *Munnini* (group) Hansen, 'Ingolf' Malacostraca, iii. p. 33.

Genus Munna Kröyer.

1839. *Munna* Kröyer, Naturhistorisk Tidsskrift, vol. ii. p. 612.
1882. ,, Chilton, Ann. Nat. Hist. ser. 5, vol. ix. p. 1.
1887. *Haliacris* Pfeffer, Krebse von Süd-Georgien, Part 1, p. 97.
1899. *Munna* Sars, Crust. Norway, vol. ii. p. 106.
1902. *Haliacris* Hodgson, 'Southern Cross' Crustacea, p. 253.
1905. *Munna* H. Richardson, Isop. N. Amer. p. 480.
1906. *Haliacris* H. Richardson, Exp. Antarct. française, Isop., p. 16.
1909. ,, Chilton, Subantarctic Is. N. Zealand, Crust., p. 650.
1910. ,, Hodgson, Nat. Antarctic Exp., Isopoda, p. 58.
1913. ,, H. Richardson, Deuxième Exp. Antarct. française, p. 19.
1916. *Munna* Hansen, 'Ingolf' Malacostraca, iii. p. 34.

The species of this genus have caused no little difficulty by the smallness and transparency of some parts and the great length and fragility of others. Some curious slips of the pen may also be noticed. Thus Sars attributes the genus to Boeck, just after writing of it as Kröyer's. Pfeffer in defining *Haliacris* states that the second to the fourth pairs of walking-legs are longer and stronger than the fifth to the seventh pairs, though his specific description shows that he means just the reverse. Hodgson in describing the mandible says of the palp, "first and third joints subequal, third the longest," his figure showing correctly the second joint as the longest. Chilton and Hodgson, with a lingering retention of the name *Haliacris*, agree that the name must be regarded as a synonym of *Munna*. Hansen points out that the character "eyes distinct" must be withdrawn from the definition given by Sars, if the genus is to include such species as *Munna cæca* Richardson, *M. truncata* Richardson, and *M. acanthifera* Hansen. But he does not notice Miss Richardson's proposal in 1908 (Pr. U.S. Nat. Mus. vol. xxxv. p. 79) to substitute the generic name *Cæcimunna* for the species *truncatus* and *Haplomunna* for the species *cæcus*. Should these proposals be adopted, Hansen's *acanthifer* would probably be allotted to *Cæcimunna*, thus withdrawing all the blind species from *Munna*. In 1913 Miss Richardson advocates the retention of *Haliacris* on the ground of the special structure of the first gnathopods in the male and their great size. This distinction would require the inclusion, along with Pfeffer's species, of *Munna palmatus* Lilljeborg, 1851, and *Munna neozelanicus* Chilton, 1892. But it is at least highly inconvenient to have the adult male in one genus, while the females and young males can be appropriately placed in another. In *M. kröyeri* Goodsir the carpal joint of the male's first gnathopod is large, while in *M. palmatus* it is very much larger, but surely this by itself should not count for generic difference. In instituting his genus Pfeffer was himself unacquainted with the full development of the first gnathopod in the adult male.

MUNNA ANTARCTICUS (Pfeffer). (Pl. V.)

1887. *Haliacris antarctica* Pfeffer, Krebse Süd-Georgien, Pt. 1, p. 97, pl. 6. figs. 28-47.
1902. ,, *australis* Hodgson, 'Southern Cross' Crust., p. 253, pl. 34. figs. 1 *a*-*d*, pl. 37.
1906. ,, ,, H. Richardson, Exp. Antarct. française, p. 16, fig. 20.
1909. ,, *antarctica* Chilton, Subant. Is. N. Zealand, Crust., p. 650, fig. 14 *b*.
1910. ,, ,, Hodgson, Nat. Antarct. Exp., Isop., pp 58-61.
1913. H. Richardson, Deuxième Exp. Ant. française, p. 19.

Mr. Hodgson says of the specimens obtained by the 'Discovery' that some of the old males "attain a length of seven millimetres." None of the Falkland Island specimens exceeded 3 mm. Yet the single example of an adult male first gnathopod is very characteristic of the advanced development. It differs slightly from the only other available figure, given by Miss

Richardson in 1906, as there the inner margin of the large carpal joint's process is serrate, in place of the well-marked inner tooth of our specimen.

In the first antennæ I found two stout joints, the second longer than the first; to the second succeeds a minute joint which I suppose to be the third joint of the peduncle. It is followed by a similar joint which should, I think, be considered the first of the slender flagellum.

In the male the second antennæ may attain a great length, fully twice that of the body, the transparent flagellum slightly exceeding that of the peduncle. Pfeffer's figure gives this flagellum without any divisions, and those which I have marked are very uncertain, notwithstanding the high magnification. As shown on the Plate the specimen carrying this long antenna on the right had on the left one very much shorter, and the peræopods on the left are rather shorter than those on the right. Mere size has to be carefully considered before it can be used in classification.

The curved third joint of the mandibular palp seems naturally to bend away from the cutting-edge rather than towards it. In the maxillipeds the broad plate of the second joint has three or four minute hooks on the inner margin and four little teeth on the truncate distal border.

The first pleopods of the male are described by Hansen as the "median lamella of the abdominal operculum of that sex," and for specific distinction he says "in reality the shape of this lamella, especially its terminal part, affords, perhaps, the sharpest and most reliable character." Unfortunately in small specimens its details are excessively difficult to determine. Even for the larger divisions of the peræon my figures cannot claim exactitude.

The specimens were obtained by Mr. Vallentin from a hulk at low water.

AMPHIPODA.

Family LYSIANASSIDÆ.

Genus TRYPHOSITES Sars.

TRYPHOSITES CHEVREUXI Stebbing.

1914. *Tryphosites chevreuxi* Stebbing, Proc. Zool. Soc., p. 355, pl. 3.

The original description states that in this species the third pleon segment "has the lower half of the postero-lateral margin convex and cut into a serration of nine little teeth." An examination of additional specimens shows the variability of this character, a small example having only three such teeth, and one somewhat larger having four on one side of the pleon and six on the other side.

In J. Linn. Soc. vol. xxix. p. 58; 1903, Mr. A. O. Walker describes specimens of *Atyloides serraticauda* Stebbing with seven teeth on the margin above discussed, instead of only two in the specimen first described. The moral which Mr. Walker draws as to the untrustworthiness of small characters for specific distinction is enforced by the additional example in *Tryphosites*, a genus remote from *Atyloides*. But it is difficult to profit by the warning when a single specimen with apparently novel characters has to be classified.

Family METOPIDÆ.

Genus METOPOIDES Della Valle.

METOPOIDES PARALLELOCHEIR (Stebbing).

1888. *Metopa parallelocheir* Stebbing, Rep. Voy. 'Challenger,' vol. xxix. p. 762, pl. 43.
1893. *Metopoides* ,, Della Valle, F. Fl. Neapel, vol. xxi. p. 907.
1906. ,, ,, Stebbing, Das Tierreich, vol. xxi. p. 186.

The specimens obtained by Mr. Vallentin at the Falkland Islands had unfortunately become too dry for satisfactory examination in detail before I attempted dissection. Beyond identifying the species I can add nothing to the description and figures supplied in the 'Challenger' report and 'Das Tierreich.' The depth of 100 metres from which the 'Challenger' specimen purports to come loses such authority as it had by comparison with Mr. Vallentin's taking of the species at very small depths. They were found by him "in the branchial sac of a simple ascidian."

Family PONTOGENEIIDÆ.

Genus PARAMŒRA Miers.

1875. *Paramœra* Miers, Ann. Nat. Hist. ser. 4, vol. xvi. p. 75 (see also Rep. Voy. 'Challenger,' vol. xxix. p. 447).

PARAMŒRA AUSTRINUS (Bate).

1914. *Paramœra austrinus* (Bate), Proc. Zool. Soc., p. 364.

Specimens which I am inclined to include in this seemingly variable species were taken by Mr. Vallentin some nine years ago at Crooked Inlet. In regard to the first of them he writes: "It was found under the mantle of the common limpet *Patella ænea*. Colour, body ivory-white with a dark red line running down directly in the median line from head to tail. Eyes fiery-red." It is remarkable that the body colouring was retained till examination in the year 1918, though the eyes had become orange rather than red.

Chevreux in 1913 describes his *Stebbingia gracilis* as having the body "teinte de blanc et de rose" and the eyes "d'un rouge vif." It also agrees with our Falkland specimens in having no accessory flagellum to the first antenna, and the telson slit for half its length, but the smoothly rounded apex of each lobe is devoid of the spinule which our specimens have, and the slender spinose peræopods cannot be reconciled with the comparatively stout and smooth lower joints of the Falkland species, of which "six more specimens removed from as many different limpets were found later." One of these smaller examples, however, proved to belong to a different genus. As to the *Paramœra* specimens, so far as I have been able to verify the details, they agree with those which I have figured in the 'Challenger' Amphipoda, pl. 76, the species being there named *Atyloides australis* (Miers).

EXPLANATION OF THE PLATES.

PLATE I.

Peltarion spinosulus (White) juv.

n.s. Lines indicating size of carapace in the adjoining dorsal view.

r., *a.s.*, *a.i.* The rostrum; first and second antennæ magnified to the same scale as the rostrum and mouth-organs.

m., *mx.* 1, *mx.* 2, *mxp.* 1, 2, 3. Mandible, first and second maxillæ, first, second, and third maxillipeds.

prp. 1, *prp.* 2. Four terminal joints of the first and second peræopods, with fingers of first to scale of the mouth-organs.

PLATE II.

Zoea of a Brachyuran.

n.s. Line showing length from apex of frontal to apex of dorsal spine in specimen figured below in lateral view.

car. Carapace more enlarged, dorsal view, frontal spine omitted.

T. Telson to the same scale as the antennæ and anterior mouth-organs.

l.s., *a.s.*, *a.i.*, *m.*, *mx.* 1, *mx.* 2. Upper lip, first and second antennæ, mandible, first and second maxillæ.

mxp. 1, 2, *prp.* 1, 3, 5. First and second maxillipeds, first, third, and fifth peræopods, to a lower scale than preceding details.

PLATE III.

Megalopa of an Oxyrrhynch.

n.s. Line showing length of specimen figured below in dorsal aspect.

car. Profile view of carapace and base of pleon.

Pl. Last three segments of pleon in dorsal view, more magnified.

a.s., *a.i.* First and second antennæ.

m., *mx.* 1, *mx.* 2, *mxp.* 1, 2, 3. Mandible (part), first maxilla (palp incomplete), second maxilla, first, second, and third maxillipeds.

prp. 1, *prp.* 4, *plp.* First and fourth peræopods (less magnified than the other details), a pleopod, and terminal joints of prp. 1 on higher scale.

PLATE IV.

Tanais nierstraszi, sp. n.

n.s. Line showing length of specimen figured below in two aspects.
oc., *a.s.*, *a.i.* Eye; first and second antennæ more highly magnified.
l.s., *m.*, *mxp.* Upper lip, mandible, maxillipeds; these, the end of prp. 5 and the urp. on higher scale than the other details.
gn. 1, *gn.* 2, *prp.* 5. First and second gnathopods and fifth peræopod.
plp., *urp.* Pleopod and uropod.

PLATE V.

Munna antarcticus (Pfeffer).

n.s. ♂. Line showing length of male specimen, roughly sketched, incomplete.
a.s., *a.i.*, ♀. Dorsal view of female; first antenna more highly magnified.
Pl. ♀, *ov.* Pleon of female highly magnified; ovum to the same scale.
m. ♂, *m.* ♀, *mxp.*, *op.* ♂. Mandibles of male and female; a maxilliped; opercular lamella of male; all more magnified than other details.
a.i. ♂, *gn.* 1, ♂, *gn.* 1, ♀, *prp.* 1, *prp.* 5. Second antenna; first gnathopod of a male (from separate specimen), first gnathopod of female, part of first peræopod, fifth peræopod; all to one scale of magnification.

21. Field-Notes on some Mammals in the Bahr-el-Gebel, Southern Sudan. By Major J. STEVENSON HAMILTON, C.M.Z.S.

[Received October 18, 1919: Read November 18, 1919.]

(With Chart.)

It should be noted that my intimate personal experience extends only to the area between Bor and Shambe, and from these points eastwards to a distance of 80 miles, N. and N.E. of Shambe 60 miles, and west of the river about 20 miles. It is only in this area that I have been resident. As regards the region between Mongalla and Bor, I have spent only two months of the dry season there, and south of Mongalla I know the country only from occasional short visits.

THIANG (*Damaliscus tiang* Heugl.).

West bank.—Through the flat country from Lado northwards to Shambe.

East bank.—From a little south of Bor northwards to the limit of the area considered.

Found east of the Nile in much greater numbers than to the west. Country probably more suitable. The great open plains in the Nuer, and in the west of the Dinka country seem especially fitted to their habits. The type found west of the river is of much deeper coloration and contrasted markings than that occurring west of it, forming perhaps a different local variety.

During the dry months Thiang may be seen on these plains in countless numbers. In the vicinity of water-pools herds of from 1000 to 2000 are common, and two or three such herds may be in sight at one time.

The habits of the Thiang appear more akin to those of the Blesbuck than to those of its other cousin the Tsessobe, which latter is never found in droves and seldom far from forest or savannah country.

In the wet season, however, the Thiang are driven from most of those great plains by the water, which covers the country during several months of the year, and at such times they break up into small family-parties of from half a dozen to a score of individuals, something after the fashion of the Tsessobe, and then roam through the bush-country or wherever there is dry ground, while large numbers doubtless migrate far to the east or south-east to higher country.

The calving season is regular, lasting from about the middle of February to about the middle of March—that is to say, it takes place just previous to the advent of the first rains, and in this assimilates closely to the habit of the Tsessobe.

While in large herds in the open, Thiang are very wary and will seldom allow approach nearer than 250 yards; probably at

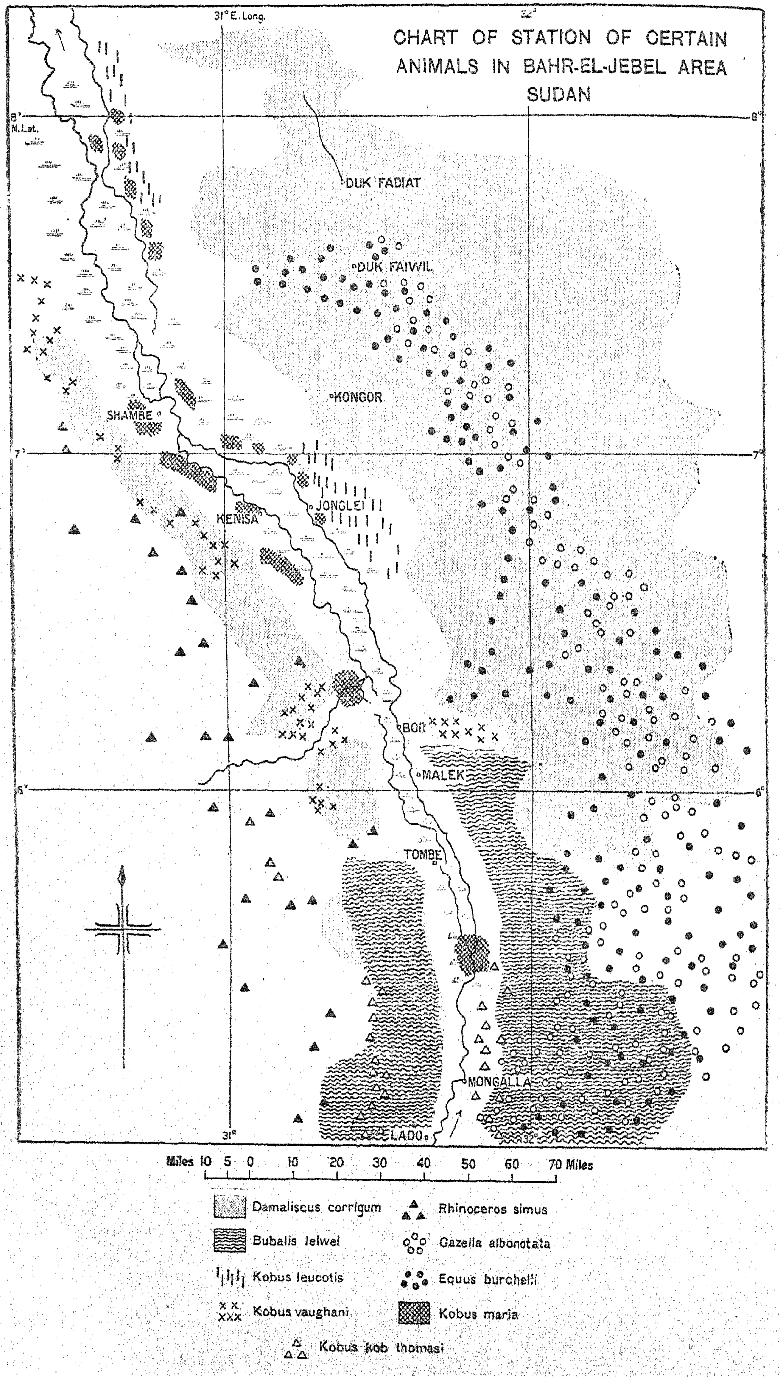


CHART OF STATION OF CERTAIN ANIMALS IN BAHR-EL-JEBEL AREA SUDAN

such a distance considering themselves safe from the lions, which follow the great herds everywhere, as also from the natives who occasionally hunt the full-grown animals. In the bush, and when in small parties, on the other hand, they appear easier to approach than most game.

The species doubtless tends to be of larger size and to bear longer horns as it trends north; but to divide it into two subraces, with a dividing-line about the latitude of Lado, is without justification. Although it is unusual to meet with Thiang south of Bor along the river, they of course exist on the great inland plains, which are a continuation of those of the Nuer and Dinka countries, and doubtless the herds make their seasonal migrations south-eastwards towards the Abyssinian and East African borders, when the winter grazing-grounds become waterlogged.

During the dry season of 1918–19 the Thiang, which had migrated westwards in immense herds, were collected in thousands over the Duk and "Toich" country between lats. 7° 15′ and 7° 45′ in the north of Bor District (E. of Bahr-el-Gebel). A virulent form of dysentery broke out among these great herds about the middle of March 1919. This disease, which in its symptoms appeared indistinguishable from the dysentery which affects human beings, was undoubtedly specific in nature and was spread by the droppings of the sick animals fouling the grass. That this was the case was proved by cattle grazing over the same ground becoming affected, while herds kept on clean ground remained healthy. The stomachs of dead animals were usually crammed with food—the lungs, liver, and heart healthy, but the gall-bladder unnaturally distended. Animals rapidly lost condition, but the disease seemed too rapid in its effects to give time for more than a staring coat and a generally pinched appearance. Animals turned away from the herd usually sought the shelter of a tree or long grass, stood for a few hours, then lay down, and presently died.

The disease was first noticed in the herds grazing in the swampy land bordering the river, which had been under water for two years and was covered with long rich thick grass, but it quickly spread to the other herds which were grazing on the short sweet grass of the Duk country 30 miles inland, and affected them to an extent quite as great as the others. I did not happen to see the remains of any animals except Thiang which had died, although there were large numbers of Roan, Giraffe, Gazelle, Reedbuck, Oribis, and a few Waterbuck and Zebra in the same country. I calculate that perhaps rather more than 10 and less than 15 per cent. of the total Thiang died in about a month. With the advent of the rains the big herds broke up, and the dry germs of disease could no longer be distributed by the wind, which probably accounted for the cessation of the sickness.

I believe that the disease, which I do not consider to have been rinderpest, although it closely resembled the latter in some of its symptoms, was originally brought to the river by herds migrating from far inland, probably from the Abyssinian boundary. I feel the more confident of this because natives stated that it often made its appearance in years of extreme drought, and that sometimes all species of game, including elephants, died from it.

HARTEBEEST (Lelwel) (*Bubalis lelwel*).

West bank.—To about 6° North (roughly the latitude of Tombe).

East bank.—Extends about as far north as Bor, and this is about its limit northwards. It is never met with in either the Lau Nuer or the Twi Dinka countries (N. and N.E. of Bor). Its northern limit is therefore practically identical on both the west and the east bank, and it slightly overlaps the southern limit of the Thiang along the river on both banks, more so on the west than on the east.

NILE LECHWE. Mrs. Gray's Waterbuck (*Kobus maria*).

The most southerly limit of this species undoubtedly is about halfway between Tombe and Mongalla at about 5° 30′ N., where in the dry season there is always a herd on an island.

North of this point they may be encountered in suitable localities on both banks of the river. A little south of the Bahr-el-Zaraf and east of the Bahr-el-Gebel they exist in the Jonglei swamps, where I have seen them. They are, however, more numerous on the west bank, not continuously, but in isolated herds considerable distances apart. An extraordinarily tame herd, which can never have had any experience of firearms, exists at one point. The Dinkas hunt the young ones with dogs, but if a man is alone, unaccompanied by a dog, and strolling along very slowly, the animals after a time will disregard his presence and may be approached within 50 yards in the open. This herd consists of about 120 full-grown animals, of which a dozen or so are dark-coloured males.

The part of the country in which this herd is found is a big reed-swamp bordering the river, opening out into a great, flat, treeless plain, which is cut up into sections by a number of swampy streams averaging 20 feet wide by 3 feet deep. Of course, during the rains this is all inundated. If the herd finds itself separated from a man by one of these swampy streams it seems to consider itself perfectly safe. When chased by natives the animals make at once for the nearest of these channels, and, dashing across, halt on the other side. Should the natives follow, the performance is repeated to the next channel. The herd spends most of its time on its open grazing-ground, where it can be seen from a distance of several miles away, and appears only to use the river reed-swamp as a place of refuge. I think, however, that the females with younger calves spend their whole time therein, until the calves are able to run and swim well. Although the usual calving-time is seemingly January and February, I have never seen any small calves with the herds, and those caught by the natives are usually, they say, found in the swamp. Of course, the dogs sometimes get a half-grown one in the open, but the natives say they never catch a full-grown one.

The habits of these animals are almost exactly those of the Zambesi Lechwe, as is their general appearance, method of holding their heads when running, and the manner in which the herd splashes through shallow water. When the plain is water-logged, I have seen the whole herd standing in water halfway up to their hocks, just as I have seen the Lechwe herds in the Kwando swamps of the South and elsewhere.

The young ones seem rather delicate and difficult to rear in captivity.

I have never seen in this herd the old dark rams without the white wither-patch spoken of by Col. Roosevelt. The younger rams have an indistinct patch, but the older the animal the more defined the patch, in my experience. There are aberrant types in all species, or possibly in some localities there may be variety of type, but I do not think anyone else has ever had so unique opportunities of studying a herd at close quarters as I have had, and in a large one, such as this, there cannot fail to be animals of all ages; besides which I have been able to watch each individual male separately, and am sure none of them display this peculiarity.

COB (*Kobus*).

Cob extend all the way along the west bank of the Bahr-el-Gebel from south of Rejaf to beyond Shambe in suitable localities. There is a very gradual but well-marked variation in type from the quite brown-eared specimens seen near Rejaf through the buff-eared types from between Mongalla and Tombe to the perfectly white-eared but rufous-bodied animals found opposite Bor. The latter agree with what is known as Vaughan's Cob in all characteristics; but they shade off gradually southwards into the typical Uganda Cob found on the same side of the river. On the east bank of the Nile "station" is much more irregular. However, Uganda Cobs are found more or less sporadically from Mongalla northwards, but, so far as I know, the intermediate type is not found, and after a gap wherein no Cobs occur, the typical *Kobus leucotis* begins to occur in the plains near Jonglei.

The "Vaughan" Cobs opposite Bor were seen in open country near forest, where a herd of some sixty grazed with several parties of Reedbuck and Thiang. They had the Cob-like habit of mounting ant-heaps to scrutinize intruders. This herd had never been molested, and I found it very tame and easy to approach so long as concealment was not attempted.

Probably the extreme permanent southern limit of the true *leucotis* is at Jonglei on the east bank of the Bahr-el-Gebel, lat. 6° 45′ N.; here they are tolerably numerous over an area of about 20 square miles in a strip along the river. They spend the nights and mornings during the dry season, as a rule, in the open plains, inland from the forest strip, where they graze and eat the loloh fruit. About 1 P.M. they begin to saunter back to the forest near the river, where they stand in the shade, and, having about 4 P.M. drunk at one or other of the forest-pools, they graze about in the forest until sunset, when they return to the open country 2 or 3 miles away.

Northwards from Jonglei no more Cob are met with south of the Bahr-el-Zaraf, where, as is well known, they are very numerous.

There are no *leucotis* on the western bank of the river south of Shambe, lat. 7° 15′, and no Uganda nor Vaughan's Cob on the east bank north of, at most, lat. 5° 15′. Thus, whereas the Uganda Cob shaded by perceptible gradients into the rufous white-eared animal found near Kenisa on the west bank, there is no form intermediate between the true White-eared Cob found on the east bank, and the true Uganda Cob found very much farther south on the same bank. As regards breeding-season, I saw no young animals during the dry season, and, from the size of the immature animals, am of the opinion they lamb about May or perhaps late April. In the wet season the White-eared Cob disappear from Jonglei and migrate long distances to the east, probably following the course of the khors towards the Abyssinian foothills in common with other game.

ZEBRA (*Equus quagga*).

Two opportunities occurred—one in early July and the other in late February—of inspecting herds at very close quarters. No animals possessed what, by any stretch of imagination, could be termed a mane, though a small minority of both sexes had a very slight ridge of hair about an inch long and very thin and ragged. This appeared about equally the case in young and in old animals—in fact, some of the colts and fillies looked like newly-hogged polo ponies. It seemed a matter of individual variation. On the other hand, a very young foal brought to me from another herd, which I did not see, had a long fully developed hog-mane exactly like that seen among the southern types of Zebra. This was from a place 20 miles from where I saw the herd in February, and was in the month of April.

The herd which I saw in July was in lat. 6° 10′, and that in February was in lat. 7° 15′.

I do not think the lack of mane can be rightly attributed to seasonalism, for one of the herds was seen well on in the cool wet season and the other in the middle of the hot dry season. In any case, I do not think there is so much as 40° Fahr. difference between the hottest day and the coldest night here all the year through.

Shadow-stripes seemed entirely a matter of individual variation. Some members of the herd, apparently without special reference to sex or age, had very strongly developed shadow-stripes on the quarters, while others showed absolutely no trace of them. Of the two stallions shot, both over 6 years old, one had strongly marked shadow-stripes, while in the other any traces of such marks were entirely lacking. The newly-born foal had indications of shadow-stripes on the quarters.

All members of both herds without exception had white ears.

The extreme northern range of the Zebra in Bor District east of Bahr-el-Gebel is at 7° 30′, and the small troops occasionally seen so far north in the height of the dry season may be regarded as stragglers.

REEDBUCK (*Redunca*).

The type of Reedbuck, formerly very common in the neighbourhood of Mongalla, was distinguished by the peculiarly wide spread of the horns. The rinderpest epidemic in 1912 almost exterminated these animals. Nevertheless, the peculiarity of the branching does not seem to have been confined to Mongalla, nor does it seem to be typical of any variety so much as of individual specialisation. I have seen several male Reedbucks as far north as Duk Fadiat, which is nearly 3 degrees of latitude north of Mongalla, possessing these same wide-spread horns, but far the larger number of the males in the locality have the ordinary type of horns well hooked forward at the tips, which one associates with Behar Reedbuck.

These Reedbuck are not only much smaller in size than, but differ considerably in their habits from, the common Reedbuck of the south. They are usually found grazing in parties with or near herds of other game in the open, which is foreign to the custom of *Eleotragus arundinum*. They also run with their necks outstretched, unlike the latter, which always carries the head high.

GAZELLE (*Gazella*).

The local Gazelle in Mongalla Province though smaller have the same general appearance and display the same habits as the Thomson Gazelle of East Africa.

The females bear weak malformed, decadent horns, and both sexes continually wag their black tails in the familiar manner of the "Tommy." The herds and single rams act when approached just as do the herds of the latter, and they scatter about when grazing among the crowds of Thiang, which here take the place of Kongoni Hartebeest.

The external markings do not vary more from those of *thomsoni* than one would expect from a local variety, while the buffy band which is spoken of by Roosevelt as existing between the black side-stripe and the white underpart is, I think, purely an individual eccentricity, and far from being universally present.

Towards the middle of very dry seasons these Gazelle migrate northwards and spread along what is known as the Duk country—where there is always sweet grass and water—as far as lat. 7° 30′, but no further. With the first rains they disappear to the south, and though a few may be found lingering well on into the summer in the low country east of Mongalla (lat. 4° 30′), I am of the opinion that the great majority migrate *very long distances towards the higher and drier country lying in the extreme S.E. of the Sudan near the East African border*, and that somewhere among these plateaux lie their summer quarters. Here they come not very far from the northern range of the true *thomsoni*, and are not separated from this animal by any natural boundary so formidable as that formed by the Sobat River and its swamps, which cut the species off from *G. rufifrons* in the north. Moreover, the Mongalla Gazelle never ranges within 100 miles of the Sobat River, the intermediate country being, in fact, unsuited to the habits of Gazelles to a considerable degree. Probably the form is almost exactly intermediate between *thomsoni* and *rufifrons*, with tendencies towards the former.

It is not found west of the Bahr-el-Gebel.

WHITE RHINOCEROS (*Rhinoceros simus*).

This animal exists all along the west bank of the Nile in the dry season, but is always very rare in the area under consideration. The natives say they drink at the river at night, and retire great distances into the forest during the day.

The above notes, which only deal with quite a small area of country (approximately 200 miles by 150) and have no pretensions to discuss the distribution of the animals mentioned outside thereof, tend to show how peculiarly patchy even within the same small area the distribution of any given species tends to be, and is an example on a small scale of what we often find and with as little apparent reason throughout the whole continent of Africa.

22. Descriptions of a new Snake from the Transvaal, together with a new Diagnosis and Key of the Genus *Xenocalamus*, and of some Batrachia from Madagascar. By The Hon. PAUL A. METHUEN, M.A., F.Z.S.

[Received October 9, 1919: Read November 4, 1919.]

(Text-figure 1.)

Genus XENOCALAMUS Gthr.

The discovery of a new form of *Xenocalamus*, described below, and the examination of the skull of *X. bicolor* Gthr. and of *X. transvaalensis*, sp. n., calls for a revision of the characters of this genus, for which I propose the following diagnosis:—

Maxillary short, with 4 or 5 solid teeth of moderate size gradually increasing in length posteriorly, followed, after a short interspace, by a pair of somewhat enlarged grooved fangs situated below the posterior half of the eye; palatines toothless or bearing a few small teeth; lower jaw with 7 to 9 rather small teeth on each side, those in the middle of the row the largest. Postfrontal bone fused with parietal. Quadrate showing tendency to enlargement and to having direct attachment to the skull, at the expense of the squamosal which may be very much reduced. Basioccipitals reniform in profile. Posterior vertebræ without hæmal processes.

Head small and elongate, not distinct from neck; snout much depressed, very prominent; rostral large, with obtuse horizontal edge, flat or excavate below; eye minute, with round pupil; nostril between a large posterior and a small anterior scale, or in a single shield which may show incipient signs of similar division. A large præocular; no loreal; no præfrontals (fused with frontal); no anterior temporal.

Body cylindrical; tail short; scales smooth without pits, in 17 or 21 rows; ventrals rounded; subcaudals in 2 rows.

Tropical Africa, as far south as the Transvaal.

Synopsis of the Species of Xenocalamus.

I. Palatine without teeth; rostral flat below.

A. Scales in 17 rows; nasal divided; 6 upper labials, third and fourth entering the eye.

1. A narrow supraocular; ventrals 218, subcaudals 24 to 36 .... *X. bicolor* Gthr.*

2. No supraocular; ventrals 229 to 239; subcaudals 31 to 36 .... *X. mechovii* Pet.

B. Scales in 21 rows; nasal entire; 5 upper labials, second and third entering the eye; ventrals 257, subcaudals 27 .... *X. michelli* Müll.

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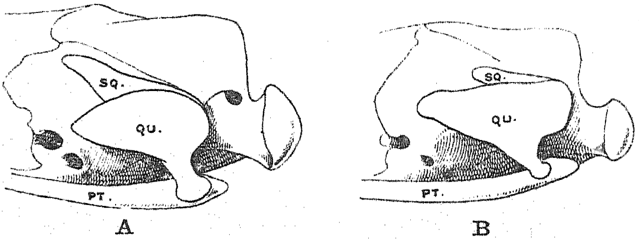
* The Transvaal Museum has an adult female specimen of *X. bicolor* (T. M. Cat. Rept., No. 1151), with exactly the same number of ventrals and subcaudals as the type; the specimen is, however, remarkable in that the third and fourth upper labials are fused into one large scale which alone enters the eye; in colour it is slate-blue above, head and neck lighter; from Rechtuit, Waterberg District, Transvaal.

II. Palatine bearing 3 or 4 small teeth; rostral excavate below; nasal entire with incipient signs of division; 5 upper labials, second and third entering eye; scales in 17 rows; ventrals 195, subcaudals 31. *X. transvaalensis*, sp. n.

XENOCALAMUS TRANSVAALENSIS, sp. n.

Description.—Maxillary bone short, with 4 solid teeth of moderate size, the posterior ones the largest, and followed after a short interspace by a pair of enlarged grooved fangs situated below the posterior corner of the orbit. Palatine bearing 3 or 4 small teeth. Lower jaw with about 9 rather small teeth on each side, those in the middle of the row the largest. Quadrate large, attached directly to the skull in its anterior half; squamosal very much reduced, that part which is visible being only two-thirds the length of the quadrate (*vide* text-fig. 1).*

Text-figure 1.



Posterior part of skulls seen in profile:
(A) *Xenocalamus bicolor*. (B) *X. transvaalensis*.

Head as broad as neck; snout depressed, prominent but not as much so as in *X. bicolor*; rostral large, rather acutely rounded, with rounded horizontal edge, excavate below, in contact with the nasal. Nostril pierced in a single scute which abuts on the rostral (the division of the rostral shield into a very small and a large scale as in *X. bicolor* is suggested by incipient sutures; in *X. bicolor* the sutures are distinct). Internasals large, forming a median suture, separated from the first upper labial by the rostral. The large præocular forms a suture with the rostral and the internasal in front. Supraocular and postocular scales minute. Frontal very large, rounded in front, more or less heart-shaped, a little more than half as long as the distance from the tip of the rostral to the posterior limit of the frontal (actual measurements being 5·2 mm. : 9·4 mm.). Parietals elongate, forming a long suture, not quite so long as the frontal. Five upper labials; the first and fifth very small, the fourth enormous, the second and third entering the eye; the third forms a short suture with the postocular. Six lower labials, third very large, first and second very small; the first pair of lower labials forms a median suture. A single pair of rather small chin-shields, which form sutures with the first, second, and third lower labials.

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* In *X. bicolor* the quadrate differs somewhat in shape and is not as large as in *X. transvaalensis*; further, the visible part of the squamosal is seen as a curved horn-shaped process extending a considerable distance across the supratemporal region (*vide* text-fig. 1).

Ventral scales 195, rounded; anal divided; 31 pairs of subcaudals.

Body cylindrical, slightly depressed.

Blue-black above, below white with dark brown transverse markings on the ventral scales; throat, lower jaw, and upper lip nearly entirely white.

Total length 414 mm., of which the tail measures 44 mm.

A burrowing snake found in sandy soil, north of the Zoutpansbergen, Northern Transvaal, near the Ingelel River, within 25 miles of the Limpopo: collected by Messrs. Noomé and Roberts, in September, 1913: it was observed to be sluggish in its movements.

Type in the Transvaal Museum, Cat. Rept. No. 1689.

BATRACHIA.

In 1913 Mr. Hewitt and I published an account of a collection of Batrachia made in Madagascar (2): I have since been able to compare many of the specimens referred to in this paper with material in European Museums, and especially with that in the British Museum. I have also been able to profit by the criticisms of Mr. G. A. Boulenger on several specimens I submitted to him. I gladly avail myself of this opportunity for thanking him for his advice on many occasions, and among other things for suggesting the names of the two new genera described below, and for pointing out their affinities to the genus *Mantidactylus*.

GEPHYROMANTIS, gen. nov.

Vomerine teeth present; digits with supernumerary phalanx; terminal phalanges dilated at end, the dilatation with shallow notch distally, reniform; lower surface of digits with ring-shaped groove; outer metatarsals united; style of sternum and omosternum long, slender, and bony; pupil horizontal; tongue well developed, bifid behind.

GEPHYROMANTIS BOULENGERI, sp. n.

Description.—Head longer than broad; snout subacuminate; nostril a little nearer tip of nostril than eye; loreal region deeply concave; canthus rostralis curved; diameter of eye very nearly equals the distance from eye to tip of snout. Interorbital space equals breadth of upper eyelid. Tympanum distinct, $\frac{1}{2}$ the diameter of eye. Fold over tympanum swollen anteriorly and posteriorly. Vomerine teeth as in *Mantidactylus granulatus.* Fingers moderate, first a little shorter than second, considerably shorter than fourth, their tips expanded into discs which are large on the third and fourth fingers, being about double the breadth of the penultimate joint; subarticular tubercles of digits and metacarpus prominent. Toes moderate, $\frac{1}{4}$ webbed, their tips expanded into discs of moderate size, not quite as large as those on third and fourth fingers; a sliced pear-shaped inner metatarsal tubercle, barely ½ length of first toe; a small outer metatarsal tubercle.

The tibio-tarsal joint of the adpressed leg reaches a point between the eye and the nostril. Heels strongly overlapping. Length of tibia ½ the distance from snout to vent, about 3½ times as long as broad.

Upper surfaces of head, body, and limbs very granular with numerous warts and elongated tubercles, which on the head and back form an irregular pattern. Belly, sides, and inner parts of thighs granular.

Habit like the *M. granulatus* section of the genus *Mantidactylus* (1).

Colour: Above dark bluish-brown with irregular lighter markings more in evidence on the head than elsewhere; upper lip, loreal region, throat, and chest mottled with dirty white and dark brown; an irregular median dirty white line on throat and chest. Upper surfaces of limbs same colour as back, the lighter brown colour of the inner parts being carried across the upper surfaces as thin irregular transverse bars.

Length from snout to vent 27·50 mm.; length of outstretched hind limb from vent to tip of fourth toe 44 mm.

Size of eggs in oviduct 2·75 mm. in diameter.

Type a female, T. M. Cat. Rept. No. 1013, and cotype No. 1012, in the Transvaal Museum; origin, Folohy, East Madagascar, 1911.

In 1913 Mr. John Hewitt and I placed these two specimens—for lack of comparative material—*pro tem.* in the genus *Mantidactylus*, the genus to which this new form is most nearly related (2).

TRACHYMANTIS, gen. nov.

Hemimantis: *H. horrida* Bttgr. Zool. Anz. 1880, p. 282; Abhand. d. Senck. Gesell., B. xii. p. 492, Taf. iii. fig. 14, 1881.

Arthroleptis: *A. horridus* Bouleng. Cat. Bat. p. 118.

Microphryne Methn. & Hwtt. (2) p. 55, preoccupied.

The only character I have to add to our original diagnosis concerns the discs of the digits, as in *Mantidactylus* and *Gephyromantis* the lower surface of the digits has the characteristic ring-shaped groove. This character in *Mantidactylus* was pointed out by Mr. Boulenger (1) when he made the genus *Aglyptodactylus* for *Mantidactylus madagascariensis*. I must also correct what was our impression at the time, that *Trachymantis* was related to *Rhacophorus*; *Gephyromantis*, which is very closely related to *Mantidactylus* and may even be a comparatively recent offshoot from a *M. granulatus*-like form, leads naturally to *Trachymantis*; the relationship can be shown thus:—

Mantidactylus: vomerine teeth; outer metatarsals separated.
Gephyromantis: vomerine teeth; outer metatarsals united.
Trachymantis: no vomerine teeth; outer metatarsals united.

In 1913 (**2**) we pointed out that we strongly suspected *Rana labrosa* to be the only truly endemic Ranid in Madagascar which was not supplied with the supernumerary phalanx to the digits; and that Böttger's "*Arthroleptis* (*Hemimantis*) *horridus*" belonged to the same genus as our "*Trachymantis* (*Microphryne*) *malagasia*." In 1914 I had an opportunity of examining Böttger's type at Frankfort with Dr. Sternfeld: we were both of opinion that *Arthroleptis horridus* should be referred to our genus, and that the two species *horrida* and *malagasia* were very closely allied. This fully confirmed our presumption as to Madagascar Ranids *.

Besides the differences cited in the two original descriptions, the following distinctions were noticed: in *T. malagasia* the snout is slightly longer as compared with the diameter of the eye and more pointed than in *T. horrida*; in the latter species the discs of the digits are larger than in *T. malagasia*. The tympanum in *T. horrida* is more visible and a shade larger than in the other species. The femurs in *T. horrida* are glandular, but lack the huge glands of *T. malagasia* which we suggested might be an abnormal development. In Böttger's species the granules on the ventral surface end in a sharp point; they might almost be described as small pointed tubercles: in our species they are replaced by swollen granules of larger size.

MANTIDACTYLUS ARGENTEUS, sp. n.

This species falls into the group with large discs to the fingers, and with granular belly (**1**): nearest ally seems to be *M. granulatus*: the upper surfaces have however no asperities.

Description.—Head flat and depressed, longer than broad; snout subacuminate, practically pointed, strongly projecting beyond the mouth; nostril considerably nearer tip of snout than eye; distance from eye to nostril $\frac{4}{5}$ diameter of eye. Tympanum distinct, $\frac{3}{4}$ diameter of eye. Interorbital space a fraction greater than breadth of upper eyelid, equal to diameter of tympanum. Loreal region concave; canthus rostralis lightly curved; fold over tympanum feebly developed. Exposed part of vomers bearing the teeth not so prominent as in *M. granulatus*, with large median space between them. Fingers well developed, their tips expanded into discs about, or a fraction more than, double the breadth of the penultimate joint; on the first finger, which is much shorter than the second, the disc is smaller than this. Toes moderate, their tips expanded into discs which are much smaller than those of the hand, being barely $\frac{1}{2}$ their diameter. Toes $\frac{3}{5}$ webbed. Inner metatarsal tubercle rather small, not prominent.

Tibio-tarsal joint of adpressed leg reaches the nostril or just short of it. Heels strongly overlapping. Distance from snout to vent $1\frac{3}{4}$ times as long as tibia, which is 5 times as long as broad.

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* *Vide* also (**3**).

Dorsal surfaces without asperities, but with very fine reticulations; some glandular granulations in coccygeal region. Belly, sides, inside of thighs, and round vent, granular.

Colour: Above brownish-purple or vinous flecked with dirty white; limbs same colour with light narrow transverse bars. Sides marbled with brown and silver; tympanum dirty white flecked with silver; lower half of eye, loreal region, snout and lips, dirty white; throat and chest silver white, yellower on chest, becoming dirty white on belly and thighs.

Length from snout to vent 32 mm.; length of leg from vent to tip of fourth toe 52 mm.

Size of egg in oviduct 2·5 mm. in diameter.

Type a female, T. M. Cat. Rept. No. 1009; cotype a juvenile specimen, toes $\frac{2}{3}$ webbed, tympanum $\frac{2}{5}$ diameter of eye, tibiotarsal joint of adpressed leg reaching tip of snout, No. 1035; both in the Transvaal Museum: origin, Folohy, East Madagascar, 1911.

PLETHODONTOHYLA TUBERIFERA, sp. n.

P. notosticta Gthr., Mthn. & Hwtt. (**2**) p. 60.

Under the name *P. notosticta*, Mr. Hewitt and I provisionally identified seven examples of this genus, indicating at the same time that our specimens were by no means typical (*l. c.*). I have since compared ours with the examples of this genus in the British Museum and find that our specimens represent a new form. Its distinguishing characters are as follows:—Head flat and depressed; loreal region very oblique; no canthus rostralis; a rounded or more or less pointed snout projecting only slightly beyond the mouth: discs of digits larger than in any other known species of the genus; on each side in the sacral region a small prominent tubercle. In the natural arrangement of the genus, *P. inguinalis* appears to be intermediate between the new species and *P. notosticta*.

Description.—Head $\frac{3}{4}$ as long as broad, flat and depressed; snout rounded or more or less pointed, extending only slightly beyond the mouth; loreal region very oblique; no canthus rostralis; interorbital region twice the breadth of the upper eyelid; tympanum distinct, $\frac{1}{2}$ or nearly equal to the diameter of eye. Tongue typical for the genus. Vomero-palatine teeth in a long chevron-shaped transverse series, interrupted in the middle, and extending just beyond the choanæ. Fingers moderate, dilated into large triangular discs, that on the third finger being $\frac{2}{3}$ the diameter of the eye; first finger considerably shorter than second, with only slightly expanded disc; hand with flat inner and outer metacarpal tubercles coalescing medianly. Toes rather short, expanded into triangular discs, that on the fourth toe being about $\frac{1}{2}$ the diameter of the eye, that on the fifth toe small. Toes free*. A flat elongated inner metatarsal tubercle, rather poorly developed.

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* In 1913 (*l. c.*) we stated that the toes had trace of webbing at the base. We wrongly interpreted the integument which is usually present in a more or less developed form at the base of webless toes in many frogs as a rudimentary webbing.

Tibio-tarsal joint of adpressed leg reaches as far as the eye.

Upper parts smooth with a prominent little tubercle on each side overlying the expanded ends of the diapophyses of the sacral vertebræ. Posterior parts of belly, sides, and of thighs near the vent, granulate.

Colour: Ground-colour dirty white; dorsal surface blotched or spotted with dull magenta, darkest on head and snout; the tubercle on sacral region surrounded by dark horseshoe-shaped blotch; a dark line from eye, through tympanum, along side nearly to a point reached by tibio-femoral joint of adpressed leg.

Length from vent to snout 30 mm.

Types in the Transvaal Museum, Cat. Rept. Nos. 1265 to 1271; No. 1269 presented to the British Museum. Origin, Ambatoharanana, forest of Central East Madagascar, 1911.

The terminal phalanx is Y-shaped; in *P. notosticta* it is broadly Y-shaped; and in *P. inguinalis* it is also Y-shaped. So I think, in the diagnosis of the genus, this bone should be described as Y-shaped or broadly Y-shaped, rather than as T-shaped as in the Brit. Mus. Cat. The internal structure of this species was examined; it is typical for the genus.

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(1) "On the Madagascar Frogs of the genus *Mantidactylus*." By G. A. Boulenger, F.R.S. P. Z. S. 1918, pp. 257–261.

(2) "On a Collection of Batrachia from Madagascar, made during the year 1911." By Paul A. Methuen & John Hewitt, B.A. Ann. Transvaal Mus., No. 2, vol. iv. 1913, pp. 49–64.

(3) "A comparative review of the Amphibian Faunas of South Africa and Madagascar, with some suggestions regarding their former lines of dispersal." By John Hewitt, B.A. Ann. Transvaal Mus., April 1911, pp. 1–11.

23. On the Variation in the Number of Dorsal Scale-rows in our British Snakes. By Miss JOAN B. PROCTER, F.Z.S.

[Received August 14, 1919: Read November 4, 1919.]

(Text-figures 1–3.)

In a valuable paper* Dr. Ruthven has drawn attention to certain points in the lepidosis of the Garter-snakes or North American *Tropidonotus* of the group *Thamnophis*, and has formulated a series of laws regarding the loss of certain rows of dorsal scales, which throw much light on phylogenetic questions. The principal of these are as follows:—

"*That the decrease in the number of scale-rows posteriorly is brought about in all of the forms of garter-snakes by the loss of certain definite rows.*

"*That the order in which these rows are lost posteriorly in the different forms is the same as in the form having the maximum number of rows for the genus.*

"*The individual, geographic, and racial variations in the number of dorsal scale-rows in the garter-snakes is brought about by the shortening and loss of the same scale-rows as are ordinarily dropped posteriorly in conformity with the taper of the body, and there is evidence that this decrease is due to a dwarfing of the body.*"

A short time ago Mr. Boulenger, who guides and encourages me in my work, gave me a copy of this most interesting paper, and suggested that I should find how far these laws apply to other snakes. I have therefore made a careful study of our three British snakes, as representing widely differing types subjected to the same climate.

In all I have found that there is this abridgment of certain longitudinal rows of dorsal scales, and that in each of these species the manner in which this takes place is highly characteristic.

On examining any snake with abridged series of scales, one at first concludes that these have been formed by the regression of rows which were complete in the primitive state. All the implicated species, however, are not being subjected to dwarfing influences, as is evidently the case with the Garter-snakes, and in some groups, notably the Vipers, evolution seems to tend towards enlargement and increased number of scales. To determine the manner in which any given abridgment has been arrived at, it is necessary to consider the scale-formula of the primitive form of the genus, and, in some cases, to make comparisons with individuals having the next highest and next lowest formula.

1. *Tropidonotus natrix* has 21 scale-rows upon what may be called the neck, the reduction to 19, brought about by the termi-

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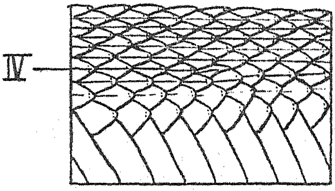
* "Variations and Genetic Relationships of the Garter-snakes." Bull. 61, Smithsonian Inst. U.S. National Museum, 1908.

nation of the 10th series, usually takes place at about the level of the 6th ventral plate—a range bearing relation to the scaling at the back of the head, rather than that of the body. Since the primitive number of series for the body is probably 19 *, it is this pair of series which would develop in species having 21. Exclusive of this, the scale-formula is 19–17. The reduction to 17 is brought about by the dropping out of the IVth series in accordance with the laws of sequence formulated by Dr. Ruthven for the Garter-snakes; which is exactly what one would expect, as these snakes also belong to the genus *Tropidonotus* in the wide sense.

19–17.

The abridged series responsible for the drop from 19 to 17 rows are unquestionably in course of reduction. The termination of the IVth series (see text-fig. 1) occurs at a point 3/5ths down the length of the body, or sometimes 5/9ths. Occasionally this series fuses with the Vth, this point being marked by a large scale bearing two converging keels. The exact range of variation where the IVth series may be dropped, is ·55 to ·60 of the length of the body †, which shows that there is very little individual variation, and proves that the scutellation of the Grass-snake is in a stable condition.

Text-figure 1.



Tropidonotus natrix, lateral view, to show termination of series IV., ⅗ths down the body.

2. *Coronella austriaca.*—On the neck this snake has 21 rows of scales, the reduction to 19 usually taking place at about the level of the 8th ventral by the termination of series V. or its fusion with IV.

The primitive number of scale-rows for this genus is 19. Series V., therefore, which is only present on the neck of *C. austriaca*, becomes progressively developed in species having 21, or more, rows of scales.

The complete scale-formula for *C. austriaca* exclusive of the neck is 19–17–15, these two pairs of abridged scale-rows being formed by reduction.

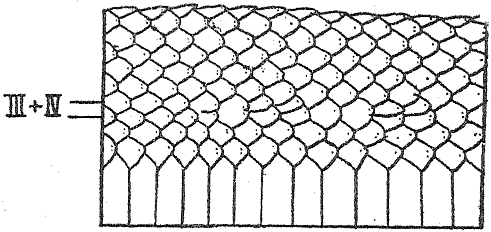
* In view of the fact that it is the most frequent number in the genus, as well as in Colubrids generally, irrespective of the affinities of the species.

† "Body" in this paper signifies the head and trunk exclusive of the tail.

19–17.

The drop from 19 to 17 rows takes place by the fusion of series IV.* with III. (see text-fig. 2) or occasionally with V. (the VIths of the original 21). The final loss of this row usually takes place at a point 3/5ths down the body, although the complete range of variation is from ·55 to ·75.

Text-figure 2.



Coronella austriaca, lateral view, to show fusion of series IV. and III., $\frac{3}{5}$ths down the body.

The fusion of series IV. with III. (or V.) is in active progress, for one finds (*a*) individuals on which the reduction from 19 to 17 rows takes place at a definite point on the third quarter of the body, anterior to which the number is invariably 19, and (*b*) individuals on which series IV. fuses, or tends to fuse, interruptedly with III. on the entire anterior half of the body, and continues in this way until that point is reached, on the third quarter of the body, where the loss is final. Between these two extremes every intermediate form may be found, the degree even varying on the two sides of the body. This instability shows a tendency for this loss to become complete.

17–15.

The reduction from 17 to 15 rows takes place by the suppression of series III. or its fusion with IV. (the VIth of the original 21), the final loss being at a point on the posterior quarter of the body, but subject within this limit to considerable variation, which suggests that this reduction is comparatively recent, and still in active progress.

3. *Vipera berus.*—The apparently most primitive form among living Vipers, *V. ursinii*, also has 19 rows of scales, and therefore *V. berus*, with scale formulæ varying from 19–17–16 to 23–21–19–17–16, must have four of its abridged series in course of production, and three in course of reduction.

23–21.

In the average individual there are 23 rows of scales immediately behind the head, the drop to 21 rows taking place by the termination of series V. at about the level of the 15th ventral. This series is in course of development, and in several specimens it crops up on the middle third of the body to a degree varying from a single scale to a complete row, which, though it commences by cropping up in an intermittent manner on this region of the body of some individuals, develops and progresses both forwards and backwards in others, and in one specimen unites with its originated portion on the neck giving this snake 23 uninterrupted rows for more than half its length. This progressive development of series V., which in *V. berus* does not ever continue beyond the anterior two-thirds of the body, evidently continues in species having 25 or more scale-rows.

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* Although in many cases the fusion is completed in such a manner as to make it impossible to say which is the supernumerary row, I judge it to be IV., as in some cases the final scales of this row are rudimentary, and also the occasional union with the Vth instead of the IIIrd points to this conclusion.

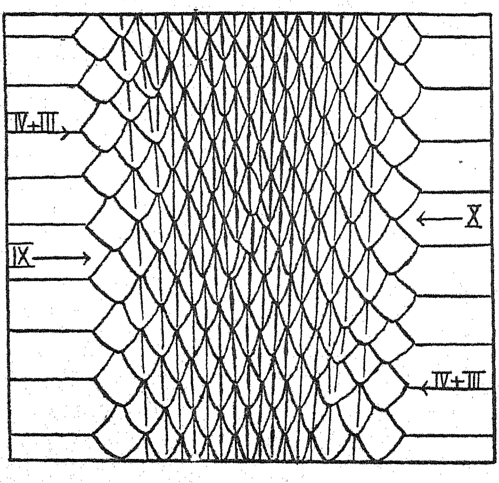
21–19.

The second pair of series in course of development is the IVth. In normal specimens which have 21 rows of scales this series terminates about two-thirds down the body, usually by fusing with the IIIrd. In specimens which have 19 rows instead of 21 it is only present on the neck; its development from this point taking place in precisely the same manner as that of series V

19–17.

The first pair of series in course of reduction is that next to the vertebral; its termination takes place on the third quarter of the

Text-figure 3.



Vipera berus, dorsal view, to show termination of series IV. on left side, fusion of series IV. with III. on right side, and termination of the penultimate series on both sides, ⅔rds down the body.

body usually two-thirds down. In the normal Viper, which has 21 rows of scales on its anterior two-thirds, this point almost invariably coincides with the termination of series IV.; and as the corresponding points vary on the two sides of the snake, a variety of combinations result, all of which have the effect of reducing the number of scale-rows from 21 to 17 in an abrupt and often highly irregular manner. One such combination of the ending series was as follows:—21–20, IVth left side: 20–19, Xth right side; 19–18, IXth left side; 18–17, IVth and IIIrd united, right side (see text-fig. 3). In some other specimens the penultimate series ended over an inch anterior to the IVth, the regression of the one pair thus overlapping the progression of the other. This overlap is always present in specimens having 23 rows, as in these the amount of regression remains the same, whilst the progression of series V. and IV. has advanced reciprocally.

17–16.

Just before the commencement of the tail there is yet another reduction caused by the vertebral row, which drops out usually within about four ventrals of the end of the body. Occasionally the loss is less advanced, and constitutes the first reduction on the tail-proper; conversely regression may be more advanced, and in one extreme instance this series ended 22 ventrals before the end of the body.

Anatomical reasons for the halting-points in the reduction and production of scale-rows.

It is clear, since the size of the dorsal scale is more or less fixed, that the number of rows is correlated with the calibre of the body, and that this number must decrease or increase, if smaller or larger forms are to be produced. Also, the series must vary in number according to the taper of the body. The posterior reductions are amply accounted for by this, but the general taper of the body seems quite insufficient to account for the constant halting-point in reduction or production of two, in the case of *V. berus* four rows, about two-thirds or three-fifths down the body.

Now the number of rows must be regulated by the normal girth of the body; or by the girth attained by necessary expansion at certain points. It also stands to reason, if scale-rows are to be dropped, in the case of reduction, that the abridgment will commence where the loss in girth will be least missed, and progress in this manner, so that the portion of body where these rows finally persist will be that part where the skin has the greatest strain imposed upon it. Conversely this will be the point where the development of new rows will commence *.

In *T. natrix* this portion is from the neck to a point just beyond the middle of the body. In the Garter-snakes when further reduction is necessary after the abridged rows have reached this point, *it takes place from the neck backwards* until complete.

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* In *Naia*, for instance, the more developed the hood, the more numerous the scales.

In *C. austriaca* the IVth, which is in process of reduction, halts at the same point, somewhere on the third fourth of the body, and when further reduction is required the whole series commence to break up by intermittent fusion with its neighbour.

It is thus obvious that the portion of the trunk-proper where the skin receives the most strain is that anterior to this halting-point, the greatest strain of all being on the middle third. The reason for this is the presence of the stomach, a fact which I have verified by the dissection of 15 spirit-specimens*, confirmed by the dissection and special study of three fresh specimens, taking particular notice of the relative positions of the pyloric sphincter, and the point where the final loss occurs in the involved scale-rows. In every case the halting-point is on a level with the pyloric sphincter, or some way posterior to it: in no case does it occur anterior to the pylorus. To test this I took a small viper enormously distended with food (spirit specimen) and stuck a pin into it where it first regained its normal girth. On examination this pin proved to have been lodged within a ventral of the point where the IVth series fused with the IIIrd, on the left side; dissection proved this point to coincide also with the pyloric sphincter; the stomach-proper in this case was distended by a large mouse. Most cases are of course less exact, as there is much individual variation, the given points usually varying a little on the two sides of the body.

If one considers a snake's manner of feeding, and the length of time that the stomach remains distended, it is not surprising that the reduction of scale-rows should be held up where the strain on the skin is so great, or that new rows should commence by out-cropping at this region.

Dr. J. C. Thomson, in his paper on ophidian anatomy†, has studied this question of the variation in the number of scale-rows, together with the external landmarks of the principal organs, the relative positions being given in term of ventrals. Of *Thamnophis ordinoides* he says:—"The relation existing between the position of the viscera and the added and suppressed scale-rows has been studied in fifty specimens of this species." "19-21-19-17, that is 19 rows forward, increasing to 21 at about the level of the heart and continuing to the end of the liver, then decreasing to 19, and further on to 17." He does not, however, mention the stomach and its physiological bearing on the question, nor does he record its position in the tables of "The *external landmarks* of the principal viscera."

The high number of rows behind the head can also be accounted for, this area of skin being subjected to the greatest strain of all, by the enormous distension of the jaws in the struggle to swallow the prey whole. What would be the use of the highly elastic ligamentous attachment of the mandible, and the loose attachment of the bones of the skull generally, if the skin over the back of the head and neck were not also capable of the highest distension? The scale-rows appear first and last upon this small area, but the development of fresh rows almost invariably halts on the neck, and recommences over the region of the stomach, afterwards continuing forwards and backwards until the scale-series is complete from the head to the level of the pyloric sphincter—the second halting-point. It is probable that this procedure in the production and reduction of scale-rows will be found to hold good for all snakes.

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* 4 *T. natrix*, 5 *C. austriaca*, and 6 *V. berus*.

† "Further Contributions on the Anatomy of the Ophidia." Proc. Zool. Soc. 1914.

Sexual dimorphism.

In accordance with these principles, it follows that the female snake should have, or tend to have, a higher number of scale-rows than the male, on account of her greater girth. Dr. Ruthven has already made this supposition[*], but finds that it is not realised in the Garter-snakes, except in the case of *T. radix*, in which the greater number of males have the formula 19–21–19–17, whilst the greater number of females have that of 21–19–17.

In *T. natrix* both sexes have the formula 19–17, and I can detect no sexual variation in the amount of abridgment of series IV. in the 25 British specimens which I have studied.

All the British specimens of *C. austriaca* in the British Museum have the formula 19–17–15. It may be that there is a sexual variation in the position of the posterior reduction, as in 8 out of 9 females this occurred from ·85 to ·96 in the length of the body, whilst in 3 out of 4 males it occurred ·75 to ·85 in the length of the body; one cannot base conclusions, however, on such small material as this, or the preceding.

In *V. berus* there is undoubtedly a tendency for the females to possess a higher formula than the males. The number of rows on the middle third of the body varies from 19 to 23. In 170 British specimens the 4 having 23 rows were all females. Mr. Boulenger, who has statistics relating to 460 European specimens, finds that 3·74 per cent. males and 2·81 per cent. females have less than 21 rows, and 2·79 per cent. males and 6·32 per cent. females have more than 21 rows. This tendency is still more marked in the Green Viper, *Atheris squamiger*[†] Hallow., in which the male has from 19 to 21, and the female 21 to 23 rows.

At present there is only one species known, in which this differentiation between the sexes is complete and constant. Mr. Boulenger[‡] has recently discovered that in the Cameroon *Bothro-*

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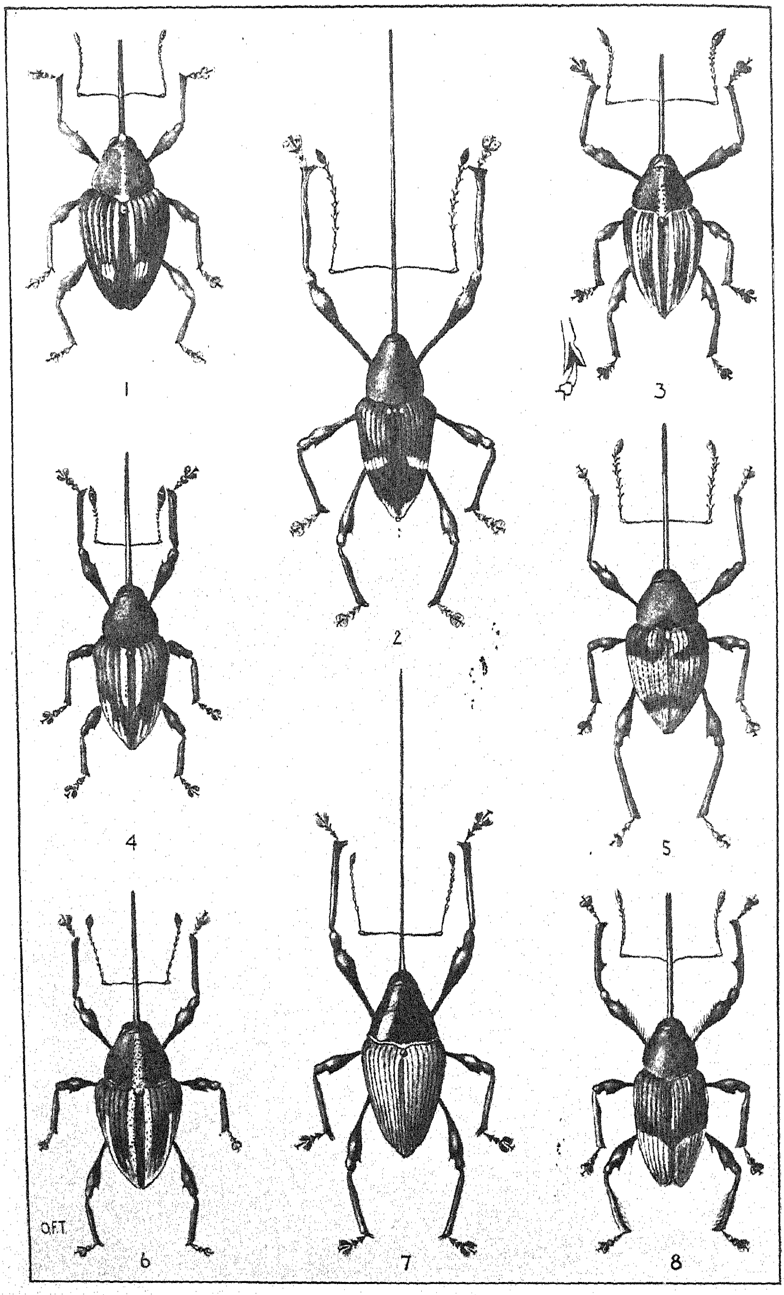
[*] *Op. cit.*

[†] Boulenger, "Batraciens et Reptiles recueillis par le Dr. Christy au Congo Belge 1912–1914." Revue Zool. Afric. vol. vii. fasc. 1, 1919.

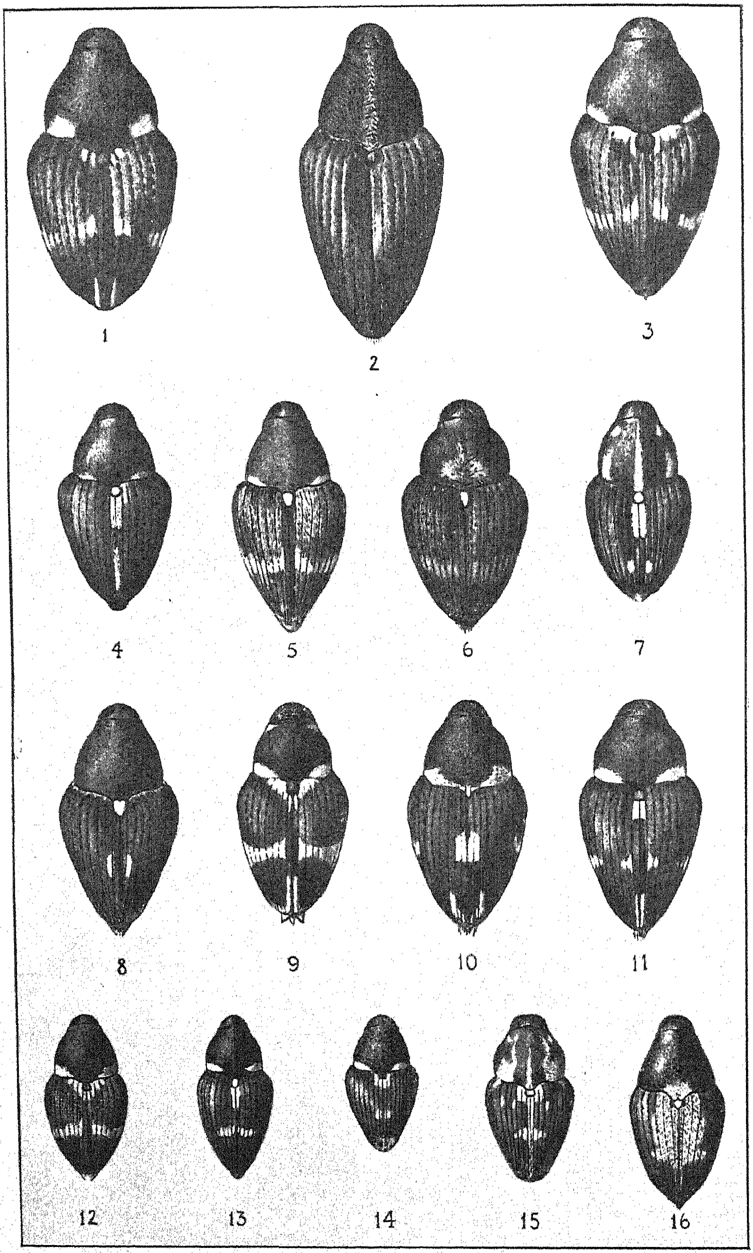
[‡] "Un cas de dimorphism sexuel chez un Serpent Africain (*Bothrolycus ater* Günth.)." Inst. de France, C. R. Ac. Sci. 1919.

lycus ater Günth. it is normal for the male to have 17, and the female 19 scale-rows on the anterior two-thirds of the body, caudad to which the number of rows is reduced to 15 in both sexes. The sexual dimorphism in this case, which so amply fulfils Dr. Ruthven's supposition, led to the sexes being described as two species, *Pseudoboodon albopunctatus* and *P. brevicaudatus* Andersson. In the female of this snake the reduction from 19 to 17 scale-rows is effected by the convergence of series VIII. and IX., two-thirds down the body, and that from 17 to 15 by the convergence of series VIII. and VII. about nine-tenths down. In the male the reduction to 17 rows is accomplished on the neck, and that from 17 to 15 takes place three-quarters of the way down the body, also by the convergence of the VIIth and VIIIth series; even this caudad reduction is therefore further advanced in the male than in the female, thus completing the sexual dimorphism of this unique species.

P. Z. S 1919. MARSHALL. Pl. I.



BORNEAN BALANINUS.



BORNEAN BALANINUS.

24. On the Species of *Balaninus* occurring in Borneo (Coleoptera, Curculionidæ). By Guy A. K. Marshall, D.Sc., F.Z.S.

[Received August 12, 1919: Read November 4, 1919.]

(Plates I. & II.*)

Mr. G. E. Bryant having succeeded during a visit to Sarawak in securing a number of weevils of the genus *Balaninus* asked me to work them out for him. On examining the literature up to 1914, and such publications since that date as are available in this country, it came as a surprise to find that not a single species of the genus had been described from Borneo. It is true that Faust (Ann. Mus. Civ. Genova, xxxiv. 1894, p. 234) has recorded the occurrence in both Borneo and Burma of *Balaninus interruptus* Kirsch (1875), but there seems to be some reason for doubting the accuracy of his identification, at least so far as his single Bornean ♀ was concerned.

Kirsch's insect was described from Malacca, and unfortunately his type is not available (being in Dresden), nor have I been able to find any species from the Malay Peninsula that can be attributed to it. On the other hand, his description applies adequately to one Indian and two Bornean forms, which represent three undoubtedly distinct species. It is more probable that *B. interruptus* will be the same as the continental species, though it would not be surprising if the Malacca insect should prove to be yet a fourth species of the group. In the circumstances it has seemed wiser to treat the Bornean species as distinct, and they are described below as *B. analis* and *B. imitator*, spp. n.

In all, Mr. Bryant took 32 different species of *Balaninus*, of which 3 were represented by single specimens in too poor condition for description. Among the Curculionidæ sent from Kuching by the late Mr. R. Shelford to the Oxford and Cambridge Museums, which I have been able to examine through the kindness of Prof. E. B. Poulton and Dr. Hugh Scott respectively, there were only 7 species, 3 of which were not met with by Mr. Bryant. Although Dr. A. R. Wallace paid special attention to the collection of Coleoptera during more than a year's stay in Sarawak, on examining his material at the British Museum, I could find only a single specimen of the genus (*B. unifasciatus*, sp. n.).

The species of *Balaninus* are certain to prove far more numerous in the tropics than would appear at present; for they would be met with only occasionally, unless specially searched for, owing to the fact that they breed in arboreal fruits and nuts, and probably therefore they will be found mainly at the tops of the forest trees. Mr. Bryant informs me that he obtained a large proportion of his specimens from the flowers of a single felled forest tree (*Vernonia arborea*) on Mt. Matang.

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* For explanation of the Plates see p. 397.

In spite of certain obvious diversities I have preferred to retain all the species here described within the genus *Balaninus* in its broad sense. The ventral structure in *B. bryanti* and the separation of the front coxæ in *B. discreticoxis* are notable departures from the normal; but in a group of which we admittedly know extremely little, undue haste in erecting new genera on single species is by no means desirable.

The strong sinuation of the lateral margin of the elytra, which has been used in the key for the primary division of the genus, will no doubt be treated by some authors as of generic value. But in the writer's opinion it does not present the features of a satisfactory generic character; it is not correlated with any other structural difference, and the two divisions created by it are no more homogeneous among themselves than is the whole undivided series. It seems not unlikely that this sinuation is in the nature of a late adaptation; for it will probably be found to be correlated with a greater activity in flight, the cutting away of the elytral margin allowing greater freedom in the use of the membranous wings.

In the following descriptions no reference is made to the sculpturing of the elytra, except in *B. glabricollis*, because it is practically similar in all the other species. In these the punctate striæ are deep and broad throughout, but narrower than the intervals, which bear transverse granular rugosities, these being coarsest near the base and becoming gradually finer behind.

I have pleasure in expressing my thanks to Miss O. F. Tassart for the great care and trouble she has taken in the preparation of her excellent drawings.

Mr. Bryant has now generously presented the whole of his fine collection of Curculionidæ to the British Museum, in which will be found the types of all the following species, unless otherwise indicated.

A Key to the Bornean Species of Balaninus.

1. (24.) Margo elytrorum lateralis profunde sinuatus supra metepisternum latissimum.

2. (3.) Segmentum ventris secundum angulo laterali posteriore valde producto fere usque ad basin segmenti quarti, segmentis primo et secundo pone coxas brevissimis, simul sumptis ibi tertio non longioribus; elytra nigra, tertia parte apicali testacea; ♂ tibiis posticis intus et femoribus anticis subtus longe fimbriatis, tibiis anticis intus dente lato armatis. 1. *bryanti*, sp. n., ♂ ♀.

3. (2.) Segmentum ventris secundum angulo laterali posteriore non aut perparum producto; elytrorum integumentum concolor; ♂ pedibus simplicibus.

4. (5.) Pronotum læve nitidum, punctis parvis sejunctis; articulus funiculi primus quatuor sequentibus simul sumptis fere æqualis. 2. *glabricollis*, sp. n., ♀.

5. (4.) Pronotum opacum, punctis magnis reticulatim approximatis, nonnumquam confluentibus; articulus funiculi primus tribus sequentibus simul sumptis brevior.

6. (21.) Segmentum ventris primum pone coxas secundo non longius.

7. (20.) Articulus funiculi primus secundo longior; pronotum regulariter reticulato-punctatum.

8. (11.) Elytra nigra, macula transversa alba singulatim pone medium ornata; stria 9 ad basin elytrorum percurrens; femora postica ultra elytrorum apicem evidenter extensa; prothorax lobis postocularibus angustis præditus.

9. (10.) Prothoracis longitudo latitudini baseos æqualis; macula alba in elytro ab interstitio tertio ad octavum extensa; mesepimerum undique dense albo-squamosum, metepisternum area triangulari nuda in angulo laterali anteriore præditum; ♂ setis in pygidio aurantiis, lacuna basali ventris minus profunda; ♀ rostro quam femore antico plus duplo longiore. 3. *bispilotus*, sp. n., ♂ ♀.

10. (9.) Prothorax latitudine baseos brevior; macula alba in elytro ab interstitio quarto ad sextum aut septimum extensa; mesepimerum squamulis albis nullis aut perpaucis, metepisternum ad basin omnino albo-squamosum; ♂ setis in pygidio nigro-brunneis, lacuna basali ventris profunda; ♀ rostro quam femore antico sesqui-longiore. 4. *excavatus*, sp. n., ♂ ♀.

11. (8.) Elytra fasciis albis nullis; stria 9 elytrorum basin non attingens; femora postica ultra elytrorum apicem non aut perparum extensa; prothorax lobis postocularibus nullis.

12. (17.) Elytra interstitio secundo conspicue pallido-squamoso, excavatione suturali inæquali in elytro dextro profundiore quam in lævo.

13. (16.) Pronotum vitta media pallida ornatum.

14. (15.) Vitta media prothoracis e squamulis transversis composita; elytra vitta pallida in interstitio sex^{to} perfecta; ♂ tibiis posticis interne supra corbulam profunde excisis. 5. *excisipes*, sp. n., ♂ ♀.

15. (14.) Vitta media prothoracis e squamulis longitudinalibus composita: elytra vitta pallida interstitii sexti in tertia parte basali obsoleta; ♂ incognitus. 6. *sesquilineatus*, sp. n., ♀.

16. (13.) Pronotum vitta media nulla; ♂ tibiis posticis interne non excisis. 7. *bilineatus*, sp. n., ♂ ♀.

17. (12) Elytra interstitio secundo non conspicue pallido-squamoso, excavatione suturali æquali.

18. (19.) Integumentum nigrum, supra squamulis fuscis inconspicuis maximam partem indutum; pronotum utrinque in dimidio basali vitta lata laterali miniato-squamosa; elytra interstitio tertio in dimidio basali sparsim, sutura in dimidio apicali late et dense miniato-squamosa. 8. *semisuturellus*, sp. n., ♂.

19. (18.) Integumentum rufo-brunneum, supra sat dense ferrugineo-squamosum, linea media pronoti et elytris versus apicem pallido-squamosis. 9. *rufulus*, sp. n., ♀.

20. (7.) Articuli duo basales funiculi æquales; pronotum crebre gyroso-carinulatum. 10. *gyrosicollis*, sp. n., ♂ ♀.

21. (6.) Segmentum ventris primum pone coxas secundo longius; sutura elytrorum in dimidio posteriore setis spiniformibus oblique elevatis armata.

22. (23.) Corpus et pedes nigri; fimbriæ tibiarum apicales rufo-flavidæ; pronotum sine vitta media pallida; scutellum subquadratum elevatum. 11. *nigrocinereus*, sp. n., ♂ ♀.

23. (22.) Caput et prothorax et pedes ferruginei, elytra nigra; fimbriæ tibiarum apicales fuscæ; pronotum vitta media pallida ornatum; scutellum depressum, longius quam latius. 12. *nigrorufus*, sp. n., ♂.

24. (1.) Margo elytrorum lateralis non sinuatus; metepisternum non dilatatum: segmentum ventris primum pone coxas secundo longius.

25. (62.) Coxæ anticæ contiguæ.

26. (59.) Antennæ articulo clavæ secundo multo latiore quam longiore.

27. (56.) Sutura elytrorum in dimidio basali evidenter depressa.

28. (53.) Scrobes antennarum prope basin infra rostrum producti; margo inferior rostri (a latere inspectus) caput attingens longe supra marginem inferiorem oculi.

29. (32.) Elytra nec fasciis nec maculis albis ornata; scutellum dense albo-squamosum.

30. (31.) Tibiæ posticæ margine dorsali sinuatæ et squamis latis indutæ; venter segmentis duobus basalibus squamis latis albis dense indutis. 13. *subpartitus*, sp. n., ♀.

31. (30.) Tibiæ posticæ rectæ et squamis angustis setiformibus indutæ; venter totus squamis angustis sparse indutus, macula parva laterali e squamis latioribus in segmento secundo excepta. 14. *mæstus*, sp. n., ♀.

32. (29.) Elytra nigra, fasciis aut maculis albis ornata.

33. (34.) Rostrum in parte basali late dilatatum; antennarum scapus brevissimus, articulis duobus basalibus funiculi brevior. 15. *tumidirostris*, sp. n., ♂.

34. (33.) Rostrum versus basin non dilatatum; antennarum scapus longus, articulis 4 aut 5 basalibus funiculi æqualis.

35. (38.) Pronotum maculis basalibus albis nullis; scutellum dense albo-squamosum.

36. (37.) Elytra macula postmediana albo-squamosa in interstitio secundo, et ibidem squamis et setis suturalibus albis in interstitio primo; ♂ segmento ventrali quinto fasciculis duobus apicalibus e setis longioribus compositis. 16. *trinotatus*, sp. n., ♂ ♀.

37. (36.) Elytra maculis postmedianis albis in interstitiis 2 et 3, nec squamis nec setis albis in interstitio primo; ♂ fasciculis ventralibus e setis brevibus cum uno solo longiore compositis. 17. *consocius*, sp. n., ♂.

38. (35.) Pronotum in utroque latere macula basali alba.

39. (40.) Dorsum squamis angustis albis et flavo-brunneis mixtis indutum; pronotum maculis basalibus albis parvis et inconspicuis; scutellum dense albo-squamosum; elytra pone medium albo-fasciata. 18. *unifasciatus*, sp. n., ♂ ♀.

40. (39.) Dorsum (maculis albis exceptis) squamis tantum fuscis indutum; pronotum maculis basalibus albis conspicuis.

41. (48.) Elytra linea brevi apicali alba in interstitio primo aut secundo; scutellum nigrum.

42. (43.) Elytra linea apicali alba in interstitio secundo; femora postica ultra elytrorum apicem longe extensa. 19. *decemnotatus*, sp. n., ♀.

43. (42.) Elytra linea apicali alba in interstitio primo; femora postica elytrorum apicem tantum breviter excedentia.

44. (45.) Elytra ad basin tantum in interstitio primo albo-vittata. 20. *quincunx*, sp. n., ♂ ♀.

45. (44.) Elytra ad basin in interstitiis 1–4 fascia curvata alba utrinque cum maculis pronoti conjuncta, et fascia secunda alba pone medium.

46. (47.) Funiculus articulo primo quam secundo paulum breviore; elytra ad apicem linea marginali albo-squamosa; ♂ segmento ventris secundo ad latera postice evidenter angulato, segmento quinto ad apicem profunde exciso et utrinque triangulariter producto; ♀ segmento quinto in medio profunde foveato. 21. *analis*, sp. n., ♂ ♀.

47. (46.) Funiculus articulo primo quam secundo paulum longiore; elytra in margine apicali non albo-squamosa; ♂ segmento ventris secundo postice truncato, segmento quinto ad apicem vix sinuato nec producto; ♀ segmento quinto non impresso. 22. *imitator*, sp. n., ♂ ♀.

48. (41.) Elytra linea alba juxta-suturali nulla.

49. (50.) Scutellum nigrum, antice profunde excisum; statura major (5–5·5 mm.). 23. *deceptor*, sp. n., ♂.

50. (49.) Scutellum integrum, squamulis albis plus minus dense indutum; statura minor (2·5–3·5 mm.).

51. (52.) Prothorax macula basali alba utrinque mesepimerum non attingente; elytra ad basin squamis albis tantum in interstitio secundo et maculis postmedianis albis in interstitiis 2, 3, 7, 8. 24. *commodus*, sp. n., ♂.

52. (51.) Prothorax macula basali utrimque mesepimero contigua; elytra ad basin squamis albis in interstitiis 1–4, et fascia postmediana in interstitiis 1–8. 25. *grypus*, sp. n., ♂.

53. (28.) Scrobes antennarum omnino laterales; margo inferior rostri caput attingens ad marginem inferiorem oculi; rostrum ad basin fronte non latius.

54. (55.) Sutura elytrorum æqualiter impressa; prothorax carina media tenui instructus; funiculus articulo primo quam secundo paulum longiore. 26. *shelfordi*, sp. n., ♀.

55. (54.) Sutura in elytro recto magis impressa; prothorax non carinatus; funiculus articulo 1=2+3+4. 27. *pusio*, sp. n., ♀.

56. (27.) Sutura elytrorum ad basin non impressa.

57. (58.) Dorsum nigrum, maculis albis definitis notatum. 28. *delicatulus*, sp. n., ♂ ♀.

58. (57.) Pronotum nigrum; elytra picea, squamulis fulvis irrorata. 29. *eugeniæ*, sp. n., ♂ ♀.

59. (26.) Antennæ articulo clavæ secundo fere duplo longiore quam latiore.

60. (61.) Elytrorum sutura ad basin non impressa: funiculus articulo 1=2+3, articulo clavæ secundo ad basin valde constricto; elytra vitta suturali lata alba in tertio basali et linea suturali angusta in dimidio apicali ornata. 30. *longiclavis*, sp. n., ♀.

61. (60.) Elytrorum sutura ad basin profunde et inæqualiter impressa; funiculus articulo 1=2+3+4+5, articulo clavæ secundo ad basin vix constricto; elytra area magna communi cervino-squamosa. 31. *sellatus*, sp. n., ♀.

62. (25.) Coxæ anticæ evidenter separatæ. 32. *discreticoxis*, sp. n., ♀.

1. Balaninus bryanti, sp. n. (Pl. I. fig. 8.)

♂ ♀. Integument black, except part of the elytra, rather more than the apical third being testaceous; the lower surface of the head, the sides of the prosternum and the black portion of the elytra thinly clothed with small hair-like scales, the basal margin of the pronotum with a single row of rather broader scales; the testaceous portion of the elytra densely clothed with broad yellow scales (except interval 1), which mostly become narrower towards the apex; the front portion of the prosternum, the meso- and metasternum with similar and equally dense scales, those on the venter being paler and narrower.

Head with the rostrum arising from about the middle of the eye (in lateral view), the forehead nearly parallel-sided and about two-thirds the width of the base of the rostrum. *Rostrum*—♂, a little shorter than the body (7 : 9), rather coarsely punctate near the base, with a broad lateral furrow ending shortly before the end of the scrobe, which latter passes beneath the rostrum at the base and does not extend beyond the antennæ; ♀, as long as the body, the basal punctures less coarse, the lateral furrow shorter and shallower. *Antennæ* inserted at (♂) or behind (♀) the middle of the rostrum; joint 1 of the funicle equal to 2+3, 2 longer than 3, 3 equal to 4, 5 to 7 shorter and subequal, but 7 a little broader; the club fusiform, joint 1 slightly longer than 2 or 3. *Prothorax* a little broader than long, broadest near the base, slightly constricted at the apex, the sides gently rounded; the basal margin very slightly produced in the middle, the apical margin almost vertical at the sides, without any trace of post-ocular lobes; the upper surface with reticulate and partly confluent punctures, with a mere trace of a median smooth line, and with short recumbent brown setæ. *Scutellum* almost circular, with a few minute pale setæ. *Elytra* more elongate than usual, the shoulders rather accentuated by a shallow sinuation just behind them, the apices separately rounded, the lateral margins very deeply sinuate above the metepisternum, the suture deeply and quite symmetrically impressed in the basal half, and striæ 9 and 10 not quite reaching the base. *Legs* thinly clothed with recumbent white setæ, all the femora with a small sharp tooth; ♂ with a short truncate process on the front coxæ, the front femora with a fringe of long hairs beneath, the front tibiæ with a broad internal tooth behind the middle, the hind femora with a long sharp tooth midway between the usual tooth and the base, the hind tibiæ strongly flattened internally and there clothed with a fringe of long hairs; ♀ with the legs simple, the inner apical face of the front tibiæ rather deeply excavated. *Venter* with segments 1 and 2 extremely short behind the coxæ, 1 being shorter than 2, and the two together about as long as 3 along the same line; the outer angle of 2 strongly produced, almost reaching the base of 4 and thus separating 3 from the elytra; the pygidium of ♂ broadly exposed and very convex, with short recumbent setæ.

Length, 3·8–4 mm.; breadth, 1·9–2 mm.

SARAWAK: 1 ♂, Mt. Matang, 1000 ft., 13. ii. 14, and 1 ♀, Mt. Merinjak, 2200 ft., 27. v. 14 (*G. E. Bryant*).

A very distinct and aberrant species, not only in its colouring, but also in the structure of the basal ventral segments and the secondary sexual characters on the legs of the ♂, the additional lower tooth on the hind femora being a very unusual feature among the Curculionidæ.

2. BALANINUS GLABRICOLLIS, sp. n. (Pl. I. fig. 7.)

♀. Black or dark piceous, shiny; the whole of the lower surface and the elytra (except the shoulders) densely covered with elongate and apically truncate fawn-coloured scales, and a row of similar scales along the basal margin of the pronotum.

Head with the rostrum arising from about the middle of the eye (in lateral view), the forehead with a central fovea, nearly parallel-sided and almost as broad as the base of the rostrum. *Rostrum* extremely long (14 mm., without allowing for the curve), porrect for two-thirds of its length, densely punctate close to the base, except for a rather broad smooth central line, without any lateral furrow or carina, the scrobe entirely lateral and not extending beyond the antennæ. *Antennæ* inserted far behind the middle of the rostrum; joint 1 of the funicle very long, as long as the succeeding 3½ joints, 3 nearly as long as 2, 4 a little shorter and equal to but thinner than 7, 5 and 6 still shorter and equal; joints 3–7 bearing recumbent setiform white scales, their density increasing outwardly; the club fusiform, clothed with fulvous pubescence, joints 1 and 2 equal and a little longer than broad, 3 distinctly shorter. *Prothorax* about as long as broad, broadest at the base, the sides scarcely rounded except just before the broad shallow apical constriction; the base marginate and produced in the middle, the apical margin rounded dorsally and without postocular lobes; the upper surface smooth and shiny, with numerous small separated punctures and no smooth central line, the sides of the prosternum with larger and closer punctures. *Scutellum* relatively small, longer than broad and with a few minute pale scales. *Elytra* elongate cordiform, the shoulders not very prominent, the sides nearly straight, the apices almost jointly rounded, the lateral margins deeply sinuate near the base; the upper surface almost flat, with comparatively narrow and shallow striæ, which become much shallower behind, striæ 9 and 10 practically reaching the base, the suture deeply and symmetrically impressed in the basal half; the intervals broad and plane, with fairly close and slightly wrinkled punctures. *Legs* very long and slender, with sparse setiform pale scales; the hind femora projecting shortly beyond the apex of the elytra and the tooth on them but little larger than that on the mid femora. *Sternum* with a deep impression along the upper edge of the metepisternum, the projecting margin bearing a fringe of overhanging scales. *Venter* with segment 1 distinctly longer than 2 behind the coxæ, the external angles of 2 scarcely produced.

Length, 8·4 mm.; breadth, 4 mm.

SARAWAK: 1 ♀, Mt. Merinjak, 2200 ft., 27. v. 14 (*G. E. Bryant*).

Differs from all the known Bornean species owing to its smooth pronotum and the impression on the metepisternum.

3. BALANINUS BISPILOTUS, sp. n. (Pl. I. fig. 2.)

♂ ♀. Rather dull black, with patches of pure white scales; the elytra with a transverse white band behind the middle extending from interval 3 to 8 or 9, and an elliptical marginal patch at the apex which does not quite reach the suture; in the ♀ only there are also a few white scales near the base of interval 2; the front of the prosternum, the mesepimeron, the mesosternal process, the whole side of the metasternum (except the apex of the metepisternum and a small triangular patch at its base) and the entire venter, densely covered with broad white scales; the coxæ, the rest of the mesosternum (except the episterna, which are bare) and the centre of the metasternum with narrower, greyish white scales. *Head* with the rostrum arising from about (♀) or above (♂) the middle of the eyes, the forehead about two-thirds the width of the rostrum at its base and with a shallow fovea. *Rostrum*—♂, only a little more than half the length of the body (6 : 11), rather strongly and closely punctate in the basal half and finely and sparsely so beyond, with a smooth central line in the basal half, a shallow punctate lateral furrow (nearly as long as the scrobe) bounded below by a low carina, below which is an impunctate and longitudinally striolate area, the scrobe passing partly beneath the rostrum at the base and extending slightly beyond the antennæ; ♀, much longer than the body (3 : 2), less strongly punctate at the base than in the ♂ and extremely minutely punctate beyond the antennæ, the lateral furrow only one-third the length of the scrobe, and the striolate area beneath it lacking. *Antennæ* inserted at (♂) or far behind (♀) the middle of the rostrum, the scape not reaching the eye; joint 1 of the funicle longer than 2, joints 3 and 4 shorter and subequal, 5 and 6 again a little shorter and equal, 7 equal to 3; the club with brown pubescence, joint 1 distinctly longer than 2, and 2 than 3. *Prothorax* as long as broad, broadest at the base, the sides gently rounded, the apical constriction very slight; the base not marginate and but little produced in the middle, the apical margin feebly arcuate, the postocular lobes feeble; the upper surface with regular reticulate punctures and a very short central smooth line, the punctures on the sides of the prosternum with rather broader intervals. *Scutellum* small, bare, usually with a transverse shallow impression. *Elytra* longer than broad (13 : 10), the lateral margins deeply sinuate near the base, the apices separately rounded; the basal sutural impression deep and not quite symmetrical so that interval 1 on the right elytron is narrower than that on the left, striæ 9 and 10 practically reaching the base; the intervals transversely rugose and on the black areas with short dark recumbent setæ, which are longer and slightly raised on the apical third of the suture. *Legs* very long and slender, especially the front femora in the ♀, the hind femora exceeding the apex of the elytra and bearing a tooth that is no larger than that on the mid femora. *Venter* with segment 1 distinctly shorter than 2 behind the coxæ, the apical angles of the latter moderately produced; segment 5 of ♂ broadly sinuate at the apex and with a broad central depression, flanked on each side at the apex by a dense erect tuft of reddish-yellow hairs, the pygidium being densely clothed with similar erect hairs; segment 1 of ♂ very broadly but shallowly impressed.

Length, 8·4–8·8 mm.; breadth, 4–4·4 mm.

SARAWAK: 1 ♂, Mt. Matang, 2000 ft., 24. xii. 13 (*G. E. Bryant*); 1 ♂, Quop, iii. 1914 (*G. E. B.*); 4 ♂ ♂, 2 ♀ ♀, Mt. Merinjak, 2200 ft., 23. v. 14 (*G. E. B.*—types); 1 ♀, Banting, 12. iv. 1915 (*G. D. Allen*). S.E. BORNEO: 1 ♂, Martapura, 1891 (*W. Doherty*).

The Martapura ♂ differs from the others in having a white spot at the base of interval 2, and the transverse band and the apical patch on the elytra linked together along intervals 8 and 9.

4. BALANINUS EXCAVATUS, sp. n.

Colouring as in *B. bispilotus*, sp. n., except that the transverse white patch on the elytra extends only from interval 4 to 6 or 7, and the white scales at the base of interval 2 in the ♀ are lacking; beneath, the scales in the centre of the prosternal white patch are much narrower than the outer ones, exposing the integument, the mesepimeron bears at most only a few white scales, the mesosternal process is clothed with narrow scales, the metepisternum has no bare basal patch, and the scales on the venter are much narrower.

The following are the principal structural differences from *B. bispilotus*:—*Head* with the rostrum arising from about (♂) or well below (♀) the middle of the eye. *Rostrum*—♂, much less strongly or densely punctate, without a smooth central line, the lateral furrow almost impunctate; ♀, much shorter, being only of the same length as the body. *Antennæ* with the scape reaching the eye in the ♀ but not in the ♂. *Prothorax* shorter than its basal width, its sides more strongly rounded. *Elytra* jointly and rather shallowly sinuate at the apex. *Venter* with segment 1 of ♂ deeply excavated and containing a short median furrow at the base; segment 5 of ♂ hardly sinuate at the apex, not depressed in the middle, and with a small curved tuft of brown hairs on each side of the hind margin, the hairs on the pygidium being blackish brown.

Length, 5·2–6·4 mm.; breadth, 3–3·2 mm.

SARAWAK: 1 ♂, 1 ♀, Mt. Merinjak, 600–2200 ft., v. 1914 (types), and 1 ♂, Mt. Matang, 3200 ft., 18. xii. 13 (*G. E. Bryant*).

The ♂ from Mt. Matang has a few white scales near the base of interval 2 on the elytra.

5. BALANINUS EXCISIPES, sp. n. (Pl. I. fig. 3.)

♂ ♀. Dull black, with yellowish-grey stripes; the head with a few white setiform scales above and below; the prothorax with a central yellowish stripe and scattered isolated white scales at the sides; the elytra with two complete yellowish stripes on intervals 2 and 6 (the scales in the former being larger), intervals 8–10 covered with pale scales, those on the basal third being narrow and whitish, the remainder broad and yellowish, intervals 3, 4 and 7 with some pale scales at the apex, and a few at the base of 4, the rest of the surface rather thinly clothed with narrow brown scales; the prosternum with only a few larger whitish scales on the intercoxal process, the sides of the meso- and metasternum densely clothed with broad yellow scales, the centre of the sternum and the whole venter fairly closely covered with narrower whitish scales.

Head with the rostrum arising from about (♀) or well above (♂) the middle of the eye (in side view). *Rostrum*—♂, much shorter than the body (3 : 5), with a smooth median line in the basal half and three rows of punctures on each side of it, without any definite lateral furrow or carina, the scrobe not quite passing beneath the base of the rostrum; ♀, rather shorter than the body (4 : 5), the punctures finer, the scrobe quite lateral. *Antennæ* inserted at (♂) or behind (♀) the middle of the rostrum, the funicle with joint 1 distinctly longer than 2, 3 longer than 4, and 4–7 almost equal; the club with joint 1 very slightly longer than 2, and 2 than 3. *Prothorax* distinctly broader than long, the sides subparallel for a short distance from the base, then roundly narrowing to the apex, the apical constriction obsolete; the apical margin feebly arcuate dorsally, the postocular lobes absent; the upper surface reticulately punctate throughout. *Scutellum* small, rounded, with a few minute setæ. *Elytra* a little longer than broad (6 : 5), the lateral margins deeply sinuate, the apices jointly sinuate; the basal sutural depression deep and asymmetrical, the edge of the right elytron being more depressed than that of the left, the apical portion of the suture without erect spine-like setæ; striæ 9 and 10 not quite reaching the base. *Legs* comparatively short, the hind femora not exceeding the apex of the elytra; the femoral teeth sharp and spine-like, the hind tibiæ of the ♂ with a deep notch on the inner edge just at the top of the corbel. *Venter* with the two basal segments of equal length behind the coxæ; segment 5 of ♂ sinuate on its posterior edge and with a shallow apical impression; the pygidium with a dense pointed tuft of brown hairs.

Length, 4 mm.; breadth, 2 mm.

SARAWAK: 1 ♂, on flowers of *Vernonia arborea*, Mt. Matang, 1000 ft., 10. ii. 14 (type), and 1 ♂ 1 ♀, Quop, iv. 1914 (*G. E. Bryant*).

6. BALANINUS SESQUILINEATUS, sp. n. (Pl. I. fig. 6.)

♀. Colour dull black, with yellowish-white stripes; the head with a few sparse scales beneath; the pronotum with a pale central stripe, which is broadest at the base and gradually narrows to the apex (the scales themselves being broad near the base and diminishing towards the apex), and a small basal pale spot on each side; the elytra with a complete stripe of broad scales on interval 2, that on 6 being obsolete in the basal third, the apical half of intervals 7 and 8 and almost the whole of 9 and 10 thinly clothed with narrow whitish scales, and intervals 3 and 4 with a few pale scales at the apex; the prosternum with a dense patch of broad white scales in front of the coxæ, and isolated narrow scales on the sides; the meso- and metasterna with separated broad scales, but these are densely packed on the mesepimeron and on the sides of the metasternum, except on a patch at the base of the metepisternum where the scales are minute; the venter with fairly dense whitish scales of intermediate width.

Head with the rostrum arising from well below the middle of the eye, the lower surface being about on a level with the lower edge of the eye. *Rostrum* shorter than the body (5 : 7), finely and sparsely punctate at the base, without any lateral furrow or carina, the scrobe entirely lateral. *Antennæ* inserted well behind the middle of the rostrum, the scape reaching the eye; the funicle with joint 1 slightly longer than 2, and 3 than 4, 4–7 almost equal in length; the club elliptical, joint 1 slightly longer than 2, and 2 than 3. *Prothorax* very slightly broader than long, the sides subparallel near the base, then roundly narrowed to the apex, the apical constriction faint: the apical margin feebly arcuate dorsally, and with no postocular lobes; the upper surface with regularly reticulate punctures. *Elytra* as in *B. excisipes*, but more rapidly narrowed behind, so that the shoulders appear more prominent; the scales on interval 2 are distinctly broader, being 3–4 deep in the broadest part and 2 deep near the apex (5 and 2 respectively in *B. excisipes*). *Legs* as in *B. excisipes* ♀, except that the internal basal sinuation of the tibiæ is distinctly deeper, and the scales on the upper surface of the hind tibiæ are rather broader than any others on the legs.

Length, 3 mm.; breadth, 1·6 mm.

SARAWAK: 1 ♀, on flowers of *Vernonia arborea*, Mt. Matang, 1000 ft., 12. ii. 14 (*G. E. Bryant*, type); 1 ♀, on flowering tree, Kuching, vii. 1900 (*R. Shelford*).

In *B. excisipes* the central stripe on the pronotum is much broader and composed entirely of transverse scales, whereas in the present species all the scales lie longitudinally, except those at the extreme base.

7. BALANINUS BILINEATUS, sp. n. (Pl. I. fig. 4.)

♂ ♀. Colour dull black, the pronotum without pale markings; the elytra with a stripe of broad, pale yellow scales on interval 2 from the base to beyond the middle (the scales 4–5 deep at its broadest), an apical patch of similar scales between stria 2 and the margin and extending forwards on intervals 5–7 as far as the termination of the stripe on 2, intervals 8–10 thinly clothed with minute setiform white scales; the prosternum with a dense antecoxal patch of broad yellowish scales, the sides with narrower isolated whitish scales; the meso- and metasternum with broad yellowish scales which are fairly dense throughout except in the middle of the mesosternum; the abdomen densely clothed with narrower whitish scales.

Head with the rostrum arising at about (♂) or well below (♀) the middle of the eye. *Rostrum*—♂, two-thirds the length of the body, rather irregularly punctate in the basal half, with a very narrow smooth central line and a punctate lateral furrow extending for about four-fifths of the scrobe, which passes beneath the base of the rostrum and not beyond the antenna; ♀, shorter than the body (7 : 9), the punctures finer, and the lateral furrow shorter. *Antennæ* inserted about (♂) or well behind (♀)

the middle of the rostrum; the funicle with the outer joints very short, 1 much larger than 2, joints 3 and 4 equal, 5–7 a little shorter and subequal, 7 as broad as long; the club elliptical and comparatively large, being about as long as the five preceding joints, joint 1 longer than 2, and 2 than 3. *Prothorax* and *scutellum* as in *B. excisipes*. *Elytra* also as in *B. excisipes*, but slightly narrower (length : breadth as 5 : 4). *Legs* comparatively short, the hind femora not exceeding the apex of the elytra, the femoral teeth sharp and spine-like; the basal sinuation of the tibiæ as deep as in *B. sesquilineatus*, the hind pair clothed above with small setiform scales like the rest of the legs and not notched in the ♂. *Venter* with segment 1 shorter than 2 behind the coxæ; segment 5 of ♂ with a small bunch of hairs on each side, the pygidium rather broadly exposed and covered with yellowish-white hairs.

Length, 3–4 mm.; breadth, 1·6–2 mm.

SARAWAK: 1 ♂ 1 ♀, Quop, iv. 1914 (*G. E. Bryant*).

8. BALANINUS SEMISUTURELLUS, sp. n.

♂. Colour dull black, the pronotum on each side with a broad stripe from the base to the middle composed of dark pink separated transverse scales, and a few pale setiform scales on the disk and at the sides; the elytra with a diffuse stripe of pale narrow scales from the base to the middle, a broad dense sutural stripe on the apical half formed of broader pale pink scales, interval 7 with a diffuse stripe of similar whitish scales, and the remaining intervals with a few white setiform scales scattered among the dark ones; the prosternum with sparse narrow white scales, a small dense ante-coxal patch of broader pink scales and a few pink scales on the sides; the meso- and metasternum with sparse white scales and a broad lateral stripe of dense pink scales; the venter with fairly dense whitish scales.

Head with the rostrum arising from about the middle of the eye. *Rostrum* comparatively short and stout, much shorter than the body (4 : 7), rather coarsely and confluently punctate on the basal section, with a very narrow smooth central line and a broad punctate lateral furrow, nearly reaching the antenna and bounded below by a distinct carina, the scrobe passing beneath the base of the rostrum and not beyond the antenna. *Antennæ* inserted just behind the middle of the rostrum, the scape not quite reaching the eye; the funicle with joint 1 longer than 2, 3 and 4 subequal, 5–7 shorter, subequal and about as broad as long; the club as long as the four preceding joints, joint 1 much longer than 2, which is but little longer than 3. *Prothorax* nearly as long as broad, broadest at the base, the sides gently rounded, the apical constriction very feeble, the apical margin truncate dorsally and without postocular lobes; the upper surface deeply and reticulately punctate. *Scutellum* almost circular, bare. *Elytra* comparatively elongate (5 : 4), the margins deeply sinuate, the apices almost jointly rounded; the sutural impression deep and almost symmetrical, but slightly inclined to the right, the apical area without raised setæ; striæ 9 and 10 almost reaching the base. *Legs* comparatively short, the hind femora not exceeding the apex of the elytra, the femoral teeth sharp and spine-like; the basal sinuation of the tibiæ rather shallow, the hind pair clothed above with broader pink and white scales. *Venter* with segment 1 shorter than 2 behind the coxæ, segment 5 simple.

Length, 2·8 mm.; breadth, 1·6 mm.

SARAWAK: 1 ♂, on flowers of *Vernonia arborea*, 8. ii. 1914 (*G. E. Bryant*).

9. BALANINUS RUFULUS, sp. n.

♂. Colour brown, the upper side fairly densely clothed with rather narrow, reddish brown scales; the pronotum with a narrow central line of longitudinally placed yellowish scales; the elytra with a large apical area clothed with broader yellowish scales and a short stripe of similar scales at the base of interval 2; the whole sternum clothed with separated broad yellowish scales which are denser on the mesepimeron and the margin of the mesepisternum, the scales on the venter being denser and narrower.

Head with the rostrum arising from well below the middle of the eye; the vertex thinly, the forehead densely covered with scaling. *Rostrum* (broken at the apex) distinctly punctate laterally at the base, but without any lateral furrow or carina, the scrobe not passing beneath the rostrum nor exceeding the antenna. *Antennæ* inserted far behind the middle, the scape almost touching the eye; the funicle with joint 1 distinctly longer than 2, and 3 than 4, 5 the shortest, 4, 6 and 7 subequal and a little longer than broad; the club about as long as the four preceding joints, joint 1 a little longer than 2, and 2 than 3. *Prothorax* a little broader than long (8 : 7), the sides subparallel for a short distance from the base, then roundly narrowed, without any apical constriction, the apical margins feebly arcuate dorsally and without any postocular lobes; the upper surface with regular reticulate punctures. *Scutellum* nearly circular, with a few minute scales. *Elytra* with the lateral margins deeply sinuate and the apices jointly emarginate; the basal sutural impression deep and asymmetrical, the edge of the right elytron being depressed below that of the left, the suture without raised setæ at the apex, striæ 9 and 10 not nearly reaching the base. *Legs* comparatively short, the hind femora not exceeding the elytra, the femoral teeth sharp and spine-like, the basal sinuation on the tibiæ well marked, the hind pair with fine setiform scales above like the rest of the legs. *Venter* with the two basal segments equal behind the coxæ.

Length, 2·6 mm.; breadth, 1·4 mm.

SARAWAK: 1 ♀, on flowers of *Vernonia arborea*, Mt. Matang, 1000 ft., 8. ii. 1914 (*G. E. Bryant*).

10. Balaninus gyrosicollis, sp. n. (Pl. II. fig. 2.)

♂ ♀. Dull black, clothed above with narrow dark brown scales mottled with whitish ones, and with a faint central paler stripe on the pronotum; beneath, with separated narrow whitish scales throughout, and without any of the usual dense patches of broader scales.

Head with the rostrum arising from well above the middle of the eye in both sexes, its upper surface being on a level with the top of the eye (♂) or a little below it (♀). *Rostrum*—♂, two-thirds the length of the body, rather coarsely and confluently punctate in the basal section, without any smooth central line, but with a very shallow broad lateral furrow reaching the antenna and bounded below by a distinct carina, the scrobe passing beneath the base of the rostrum and extending shortly beyond the antenna; ♀, seven-eighths the length of the body, the lateral furrow scarcely shorter, and the punctures rather finer. *Antennæ* inserted behind the middle of the rostrum in both sexes, the scape not reaching the eye; the funicle with the two basal joints equal, 3 slightly longer than 4, 5–7 a little shorter and equal in length; the club short, ovate, as long as the two preceding joints, joint 1 slightly longer than 2, and 2 than 3. *Prothorax* slightly broader than long (6 : 5), broadest at the base, the sides rather strongly rounded, with a distinct apical constriction, the apical margin truncate dorsally and without postocular lobes; on the upper surface the reticulate punctures have coalesced so that the interspaces form numerous fine sinuous ridges. *Scutellum* longer than broad, with fairly dense pale setiform scales. *Elytra* elongate (4 × 3), the margins distinctly sinuate, the apices jointly rounded; the basal sutural impression comparatively shallow and asymmetrical, being almost entirely confined to interval 1 on the right elytron, the apical portion of the suture without raised setæ; striæ 9 and 10 not reaching the base. *Legs* moderately long, the hind femora slightly exceeding the end of the elytra, the femoral teeth sharp and spine-like, the tibiæ with the basal sinuation feeble and clothed only with setiform scales. *Venter* with segment 1 shorter than 2 behind the coxæ.

Length, 5·8–6·4 mm.; breadth, 2·4–3 mm.

Sarawak: 3 ♂ ♂, 2 ♀ ♀, Quop, iv. 1914 (types), and 2 ♂ ♂, Puak, v. 1914 (*G. E. Bryant*).

The sculpture of the pronotum and the short antennal club are very distinctive characters.

11. Balaninus nigrocinereus, sp. n. (Pl. I. fig. 5.)

♂ ♀. Colour dull black, the upper surface covered with rather sparse short hair-like white scales (producing a dull grey effect) and with the following black patches on which the scales are dark: the forehead and vertex of the head, a large triangular patch in the middle of the base of the pronotum, a transverse band on the elytra before the middle extending from stria 2 to the margin and including the whole shoulder and the base from stria 4 to the margin, and a complete subapical transverse band about ½ mm. wide; on the lower surface the scales are rather wider, except on the sides of the prosternum, the middle of the metasternum, and on the whole of the last three ventral segments; on the mesepimeron and at the sides of the first two ventral segments the scales are larger and closer together, and on the front part of the prosternum they are almost round and separated.

Head with the rostrum arising above the middle of the eye (in side view), its upper edge being on a level with (♀) or above (♂) the top of the eye. *Rostrum*—♂, shorter than the body (10 : 13), rather more distinctly punctate than usual in the apical half (especially at the sides), in the basal half with a smooth central line, and two rows of punctures on each side of it, below these a lateral furrow as long as the scrobe and containing a single regular row of punctures, its lower edge being distinctly carinate, the scrobe passing beneath the rostrum at the base and not extending in front of the antennæ; ♀, also shorter than the body (10 : 12) and rather more slender than that of the ♂, the punctures finer (except close to the base) and the lateral furrow slightly shorter. *Antennæ* inserted slightly behind the middle of the rostrum in both sexes, the joints of the funicle with pale recumbent setæ, the scape not nearly reaching the eye; joints 1 and 2 of the funicle equal, 3 longer than 4, 4–5 subequal, 7 equal to 3; the club with yellowish-grey pubescence, joint 1 longer than 2, and 2 than 3. *Prothorax* broader than long (5 : 4), the sides almost parallel for a short distance from the base, then strongly rounded, the apical constriction well marked; the apical margin truncate dorsally and with feeble ocular lobes; the upper surface with regularly reticulate punctures and no distinct central line. *Scutellum* subquadrate, covered with dense white scales, except a narrow strip on each side. *Elytra* slightly longer than broad (8 : 7), the apices almost jointly rounded, the lateral margins deeply sinuate; the basal sutural impression rather shallow and asymmetrical, interval 1 of the right elytron being lower than that of the left, the apical third of the suture with erect black spine-like bristles, the striæ 9 and 10 not reaching the base. *Legs* elongate, the hind femora distinctly exceeding the elytra; the femoral teeth long and sharp, especially that on the hind pair; the second joint of the hind tarsi longer than broad. *Venter* with segment 1 longer than 2 behind the coxæ; segment 5 of ♂ not impressed and with a stout erect seta on each side at the hind margin.

Length, 4·8–5·2 mm.; breadth, 2·4–2·8 mm.

SARAWAK: 1 ♂ 1 ♀, on flowers of *Vernonia arborea*, Mt. Matang, 1000 ft., ii. 1914 (*G. E. Bryant*).

12. BALANINUS NIGRORUFUS, sp. n. (Pl. I. fig. 1.)

♂. General colour ferruginous, the elytra black; the forehead and a narrow central stripe on the pronotum with dense yellow scales, the sides of the latter with scattered and narrower yellow scales; the elytra with the following yellow scaling: a dense stripe on interval 2 from the base to the middle, a transverse postmedian band on intervals 3–5, and widely scattered isolated scales elsewhere, interspersed with hair-like white scales; the underside for the most part rather thinly clothed with narrow yellowish scales, a compact patch of broad creamy scales before the front coxæ, and a similar patch on the mesepimeron and on the whole side of the metasternum.

Head with the rostrum arising from above the middle of the eye. *Rostrum* about half the length of the body, with five narrow carinæ at the base, the intervening striæ being shallowly punctate, the scrobes passing beneath the rostrum at the base and scarcely extending beyond the antennæ. *Antennæ* inserted distinctly beyond the middle of the rostrum, the scape not reaching the eye; the funicle with joint 1 a little longer than 2, joints 3 and 4 equal, 5 and 6 a trifle shorter and equal, 7 equal to 3; the club with joint 1 longer than 2, and 2 than 3. *Prothorax* a trifle broader than long, the sides slightly rounded, the apical constriction almost obsolete; the apical margin slightly arcuate dorsally, with very feeble postocular lobes; the upper surface with rather shallow and partly confluent reticulate punctures. *Scutellum* elongate and clothed with dense yellow scales. *Elytra* slightly longer than broad, the lateral margins sinuate, the apices almost jointly rounded; the basal sutural depression broad and deep, and almost symmetrical, the apical third of the suture with short, obliquely raised scales, striæ 9 and 10 not reaching the base. *Legs* comparatively short, the hind femora not exceeding the apex of the elytra, the femoral teeth short and sharp; the front coxæ with a conical process; the hind tibiæ with three-fourths of the upper surface clothed with broad yellow scales, all the remaining scales on all the legs being setiform and white. *Venter* with segment 1 much longer than 2 behind the coxæ.

Length, 4·6 mm.; breadth, 2·6 mm.

SARAWAK: 1 ♂, Kuching, 1897 (*R. Shelford*. type); 1 ♂, Quop, 7. iv. 1914 (*G. E. Bryant*).

13. BALANINUS SUBPARTITUS, sp. n. (Pl. II. fig. 6.)

♀. Colour black, variegated with dark brown, bright fawn and white scales; the head beneath with small separated white scales; the pronotum with scattered fawn and white scales at the sides and with a broad median stripe of elongate fawn scales, which is broadest near the base and gradually narrows in front, the scales converging towards a point on the median line behind the middle; the scutellum with dense silvery white scales; the elytra thinly clothed for the most part with fawn or brown scales and a few scattered white ones, with a very indefinite transverse band behind the middle formed principally of white scales; the prosternum with large separated white scales on the antecoxal area and fine white and brown scales at the sides; the rest of the sternum with narrow white and fawn scales, except for a dense patch of white ones on the mesepimeron; the venter with dense white scaling on the two basal segments, and fawn scales on the others.

Head with the upper surface of the rostrum on a line with the top of the eye. *Rostrum* strongly bent downwards beyond the middle, about two-thirds the length of the body, strongly punctate in the basal section, with a low central carina, as well as a lateral one, but no lateral furrow, the scrobe passing beneath the base of the rostrum but not exceeding the antenna. *Antennæ* inserted far behind the middle of the rostrum; the funicle with the two basal joints equal, 3 longer than 4, 4–7 subequal and with appressed white setæ; the club ovate, as long as the two preceding joints and clothed with golden pubescence, joint 1 rather longer than 2, and 2 than 3. *Prothorax* much broader than long (10 : 7), broadest at the base, the sides strongly rounded, the apical constriction deep, the apical margin truncate dorsally and with distinct postocular lobes; the upper surface with deep reticulate punctures. *Scutellum* strongly elevated, longer than broad. *Elytra* with the lateral margins not sinuate, the apices jointly rounded, the sutural impression rather shallow and asymmetrical, interval 1 of the right elytron being lower and broader than that of the left, the apical half of the suture with stout raised spine-like bristles, striæ 9 and 10 not nearly reaching the base. *Legs* moderately long and stout; the hind femora somewhat exceeding the end of the elytra, the femoral teeth broad and sharp, that of the hind pair broadly laminate and ending in a sharp point; all the tibiæ clothed above with broader scales, the basal sinuation obsolete on the anterior pairs, but well marked on the hind one, the upper edge of which is distinctly sinuate.

Length, 4·4–4·6 mm.; breadth, 2·5–2·6 mm.

SARAWAK: 1 ♀, on flowers of *Vernonia arborea*, Mt. Matang, 1000 ft., 12. ii. 1914, and 1 ♀, Mt. Merinjak, 1500 ft., 25. v. 1914 (*G. E. Bryant*).

14. BALANINUS MŒSTUS, sp. n.

♀. Black, thinly clothed above with recumbent white setæ and without any markings formed of scales; the scutellum with dense white scales; the lower surface thinly clothed with white setæ or narrow scales, with the following broader white scales: a few on the prosternum in front of the coxæ, a dense patch on the mesepimeron, a small patch at the apex of the metepisternum, and a small lateral patch on the 2nd ventral segment.

Head with the rostrum arising from above the middle of the eye. *Rostrum* shorter than the body (5 : 7), punctate at the base, with a smooth central line and a very shallow punctate lateral furrow, bounded below by a fine carina; the scrobe passing beneath the rostrum at the base and not exceeding the antenna. *Antennæ* inserted a little behind the middle of the rostrum, the scape not reaching the eye; the funicle with joint 1 very slightly longer than 2, 3 a little longer than 4, and 4–7 subequal; all the joints with a few recumbent white setæ; the club about as long as the two preceding joints and with joint 1 distinctly longer than 2. *Prothorax* broader than long (11 : 9), broadest at the base, the sides rather strongly rounded, the apical margin slightly arcuate dorsally and without any postocular lobes; the upper surface with reticulate punctures and a low median carina. *Scutellum* slightly raised and a little longer than broad. *Elytra* agreeing with the description of those of *B. subpartitus*, but more pointed behind. *Legs* rather long and stout, the hind femora exceeding the apex of the elytra; the femoral teeth comparatively small; the tibiæ clothed only with setiform scales, the dorsal edge straight, and the basal sinuation very shallow.

Length, 5·5 mm.; breadth, 3 mm.

SARAWAK: 1 ♀, Quop, 6. iii. 1914 (*G. E. Bryant*).

15. BALANINUS TUMIDIROSTRIS, sp. n. (Pl. II. fig. 10.)

♂. Black, with blackish recumbent setæ, and the following markings formed of rather broad white scales: the prothorax with a large basal patch on each side, linked together by a narrow band along the base and continued outwards so as to join up with the mesosternal patch; the elytra with a common square median patch extending on each side to stria 2, a broad transverse band on each side about the middle extending from stria 6 to the margin, a short stripe near the apex of interval 3, a small spot near the apex of interval 2, a fringe of single white scales along the apical margin and a few narrow white scales sparsely scattered on the black areas; the scutellum with dense white scales; the lower surface fairly densely clothed with white scales, but more thinly so on the sides of the prosternum and on the basal half of the metepisternum.

Head with the upper edge of the rostrum above the top of the eye. *Rostrum* less than half the length of the body (5 : 11), strongly curved downwards from the base, thick at the base and gradually widening to the insertion of the antennæ, then abruptly narrowed and becoming cylindrical and shiny, with rows of fine punctures; the basal area opaque and rugose, with three distinct carinæ; the scrobe passing immediately beneath the rostrum, so that the scape in repose is quite invisible from above. *Antennæ* inserted well behind the middle of the rostrum; the scape very short (shorter than the two basal joints of the funicle together), the club forming nearly half its length, and not quite reaching the eye; the funicle thinly clothed with recumbent light brown setæ, joint 1 a little longer than 2, and 3 than 4, 5–7 shorter and equal to one another; the club nearly as long as the three preceding joints, the apex obtuse and joint 1 distinctly longer than 2. *Prothorax* somewhat broader than long (5:4), broadest at the base, the sides almost straight and slightly converging from the base to the middle, then rounded, and strongly constricted at the apex; the apical margin truncate dorsally and with feeble post-ocular lobes; the upper surface with deep reticulate punctures. *Scutellum* small and narrow, twice as long as broad. *Elytra* with the shoulders very sloping, the conjoint apices shallowly sinuate, the sutural impression shallow and asymmetrical, the sutural margin of the right elytron being distinctly sinuate, and the apical half of the suture with raised interlocking setæ; striæ 9 and 10 not nearly reaching the base. *Legs* not long, the hind femora not extending beyond the elytra; the femoral teeth long and sharp, the tibiæ with the basal sinuation shallow. *Venter* with segment 1 flattened in the middle; segment 5 with the apical margin broadly sinuate, the two angles bearing a tuft of brown hairs; the pygidium with erect brown hairs shorter than the ventral tufts.

Length, 4·5 mm.; breadth, 2·2 mm.

SARAWAK: 2 ♂♂, Kuching (*R. Shelford*).

The structure of the rostrum distinguishes this species from all the others here described, but it is probable that the character may prove to be less pronounced in the female sex; the concealment of the scrobe and the shortness of the scape are also peculiar characters.

16. BALANINUS TRINOTATUS, sp. n. (Pl. II. fig. 8.)

♂ ♀. Colour dull black, thinly clothed above with narrow brown scales interspersed with white ones, the latter frequently deciduous but always present along the base of the elytra, which also bear an elongate dense patch of broader white scales on interval 2 behind the middle and a few white scales and bristles on interval 1 at the same place; the scutellum with dense white scaling; the lower surface clothed with fairly broad but isolated white scales, and with much denser patches on the mesepimeron, at the posterior angles of metasternum, and along the sides of the abdomen.

Head with the rostrum arising from well above the middle of the eye, its upper surface being a little above the level of the top of the eye in both sexes. *Rostrum* about three-fifths the length of the body in both sexes, stout in the basal half and distinctly narrower beyond the antennæ; the basal area with two irregular rows of punctures on each side of the smooth median line, then a broad lateral furrow, edged below by a sharp carina; the scrobe passing beneath the rostrum at the base. *Antennæ* inserted at about the middle of the rostrum in both sexes, the scape not nearly reaching the eye; the funicle with joint 1 as long as 2 and half of 3, joints 3–5 gradually diminishing, and joints 4, 6 and 7 subequal in length; the club a little longer than the three preceding joints, and with joint 1 distinctly longer than 2. *Prothorax* nearly as long as broad (5 : 6), broadest at the base, the sides gently rounded, the apical constriction shallow, the apical margin truncate dorsally and with feeble postocular lobes; the upper surface with shallow reticulate punctation and occasionally with a faint central carina. *Scutellum* a little longer than broad. *Elytra* with the lateral margins not sinuate, the apices jointly rounded, the sutural impression moderately deep and quite asymmetrical, being almost entirely confined to the right elytron and extending backwards to the top of the declivity, and the apical third of the suture set with raised interlocking black bristles. *Legs* moderately long, thinly clothed with white setiform scales; the hind femora shortly exceeding the apex of the elytra, the femoral teeth rather long and sharp; the tibiæ with the dorsal margin straight and the basal sinuation very shallow. *Venter* of ♂ with two tufts of fairly long yellowish setæ on the apical margin of segment 5; the pygidium with dense erect blackish setæ.

Length, 3·5–4·5 mm.; breadth, 2–2·5 mm.

SARAWAK: 2 ♂ 5 ♀, Kuching, vii. 1900 (*R. Shelford*); 1 ♂ 1 ♀, Mt. Matang, 1000 ft., xii. 1913 (*G. E. Bryant*, type).

17. BALANINUS CONSOCIUS, sp. n

♂. Very closely allied to *B. trinotatus*, sp. n., and apart from its larger size, differing only in the following characters:—The club of the antennæ proportionately smaller, being a little shorter than the three preceding joints; the prothorax distinctly more transverse; the elytra with a post-median patch of white scales on interval 3 similar to that on 2, but a little shorter, without any white scales on interval 1 and with the sutural bristles entirely black; the fifth ventral segment of the ♂ with the apical tufts composed of very short setæ and a single long one.

Length, 5·2 mm.; breadth, 3 mm.

SARAWAK: 1 ♂, Mt. Matang, 1000 ft., 26.i.1914 (*G. E. Bryant*).

18. BALANINUS UNIFASCIATUS, sp. n. (Pl. II. fig. 5.)

♂ ♀. Black, subnitid, thinly clothed above with narrow white and light brown scales, and with markings formed of broader white scales; the pronotum with about a dozen broad white scales at each basal angle; the scutellum with dense white scales; the elytra with a postmedian macular white band lying between striæ 1 and 8 or 9; the sternum clothed with separated white scales and the usual denser patches, and the abdomen with denser scaling throughout.

Head with the rostrum arising from about the middle of the eye in both sexes. *Rostrum*—♂, shorter than the body (3 : 5), the basal portion with a single row of punctures on each side, followed by a distinct lateral furrow which is bounded below by a sharp carina, the scrobe passing beneath the base of the rostrum and not exceeding the antenna; ♀, longer than the body (13 : 11), the basal portion with two rows of punctures on each side and the lateral furrow less distinct. *Antennæ* inserted at (♂) or far behind (♀) the middle of the rostrum, and the scape not nearly reaching the eye; the funicle with joint 1 a trifle longer than 2, 3 longer than 4, and joints 4–7 subequal; the club equal to the three preceding joints, its first joint distinctly longer than the second. *Prothorax* broader than long (11 : 8), broadest at the base, with the sides gently rounded, and shallowly constricted at the apex, the apical margin truncate and with very feeble postocular lobes; the upper surface with closely reticulate punctures. *Scutellum* longer than broad. *Elytra* with the lateral margins not sinuate, the apices jointly rounded, the sutural impression very shallow and confined to the right elytron, the raised sutural bristles varying from yellowish or light brown to blackish. *Legs* thinly clothed with white setiform scales; the hind femora distinctly exceeding the elytra, the tooth on the femora dilated at the base; the tibiæ straight and without any basal sinuation. *Venter* of ♂ with the basal segment merely flattened in the middle and not impressed, segment 5 also somewhat flattened and with two isolated erect hairs on the apical margin; the pygidium with a dense tuft of erect white setæ.

Length, 2·75–4·25 mm.; breadth, 1·5–2·25 mm.

SARAWAK: 1 ♂, Simunjon, 1855 (*A. R. Wallace*, type); 1 ♀, Kuching, 16. vii. 1900 (*R. Shelford*).

19. BALANINUS DECEMNOTATUS, sp. n. (Pl. II. fig. 1.)

♀. Dull black, thinly clothed above with recumbent blackish narrow scales or setæ and with markings formed of broad white scales; the pronotum with a basal trapezoidal white patch on each side, the base of which lies between striæ 4 and 8 of the elytra; the elytra with a few white scales at the base of intervals 2 and 3, behind the middle a transverse white patch between striæ 1 and 3 and another on a line with it between striæ 5 and 9, and finally a short white line at the apex of interval 2; the lower surface for the most part thinly clothed with widely separated narrow white scales, with the following parts covered with dense broader scales: the antecoxal area of the prosternum, the mesosternal process, the mesepimeron and a part of the mesepisternum adjoining it, the basal external angle of the metasternum, and a large lateral patch on the two basal ventral segments.

Head with the rostrum arising from about the middle of the eye. *Rostrum* slender, distinctly longer than the body (17 : 14), with two rows of very fine punctures on each side in the basal portion and beneath them an obsolescent punctate lateral furrow, bounded below by a carina; the scrobe passing beneath the rostrum at the base and not exceeding the antenna. *Antennæ* inserted far behind the middle of the rostrum, the scape not reaching the eye; the funicle with joint 1 very slightly longer than 2, and 3 longer than 4, joints 4, 5 and 7 subequal and 6 a little shorter; the club as long as the preceding 2½ joints, its first joint nearly twice as long as its second. *Prothorax* broader than long (6 : 5), broadest at the base, with the sides almost straight and gradually narrowing from the base to the middle, then rounded and with a distinct but shallow apical constriction, the apical margin truncate dorsally and without any postocular lobes; the upper surface regularly and reticulately punctate throughout. *Scutellum* subquadrate, with a few minute brownish scales. *Elytra* with the lateral margins not sinuate, jointly rounded at the apex, the sutural impression very broad, deep and almost symmetrical, the apical third of the suture with raised interlocking black bristles. *Legs* long and slender, thinly clothed with white setiform scales; the hind femora with almost the whole clavate portion extending beyond the elytra, the tooth on the femora triangular at the base; the tibiæ straight, without any basal sinuation.

Length, 5·5 mm.; breadth, 3 mm.

SARAWAK: 1 ♀, Lundu, 6. i. 1914 (*G. E. Bryant*).

20 BALANINUS QUINCUNX, sp. n. (Pl. II. fig. 11.)

♂ ♀. Black, dull or subnitid, thinly clothed above with blackish narrow scales or setæ, and with markings formed of broad white scales; the pronotum with a transverse elliptical basal white patch on each side extending from stria 3 almost to the mesepimeron; the elytra with a short white stripe at the base of interval 1, behind the middle a transverse macular patch on intervals 2 and 3, on the same line with it a band on intervals 7–10 (or 6–10), and a short apical white stripe on interval 1; the lower surface fairly closely covered with separated broad white scales, with the usual denser lateral patches, that on the prosternum extending upwards along the apical constriction to the level of the middle of the eye.

Head with the rostrum arising well above the middle of the eye, its upper surface being on a level with the top of the eye in both sexes. *Rostrum*—♂, two-thirds the length of the body, the basal portion coarsely punctate, with a smooth median line and a broad lateral furrow bounded below by a sharp carina, the scrobe passing beneath the rostrum at some distance from the base and distinctly extending beyond the antennæ; in the ♀, nearly as long as the body and more strongly curved, the punctation much finer and the lateral furrow less distinct. *Antennæ* inserted at (♂) or somewhat behind (♀) the middle of the rostrum, the scape not nearly reaching the eye; the funicle with the two basal joints equal, 3 longer than 4, and joints 4–7 subequal; the club about equal to the three preceding joints, and its first joint distinctly longer than the second. *Prothorax* (♂) distinctly transverse, the sides subparallel from the base to the middle, then strongly rounded and with a deep apical constriction, the apical margin truncate dorsally and with no trace of post-ocular lobes; in the ♀ the sides are gently and regularly rounded, and with hardly any apical constriction; the upper surface coarsely and reticulately punctate throughout. *Scutellum* slightly longer than broad, with a few dark scales. *Elytra* with the lateral margins straight, the apices jointly sinuate, the sutural impression confined to the right elytron, shallow and extending from the apex of the basal stripe to the top of the declivity, and the apical third of the suture with raised interlocking black bristles. *Legs* rather thinly clothed with white setiform scales, the hind femora extending shortly beyond the elytra, and the tibiæ straight and with a shallow basal sinuation. *Venter* of ♂ with the anal segment simple and with an apical fringe of yellowish setæ; the pygidium with long dense erect brown setæ.

Length, 4·5 mm.; breadth, 2·5 mm.

SARAWAK: 1 ♂, Mt. Matang, ii. 1914 (type), and 1 ♀, Quop, iv. 1914 (*G. E. Bryant*).

Like a small *B. imitator*, sp. n., with reduced white markings, except that the basal stripe on interval 1 of the elytra is at least twice as long, the rostrum is more coarsely punctate, the last ventral segment of the ♂ lacks the erect hairs, and the setæ on the pygidium are much longer.

21. BALANINUS ANALIS, sp. n. (Pl. II. fig. 9.)

♂ ♀. Dull black, thinly clothed above with recumbent blackish scale-like setæ, with markings formed of dense broad white scales; the prothorax with a large transverse basal white patch on each side extending from the mesepimeron inwardly as far as stria 3 of the elytron, and a vertical lateral band on each side of the apex extending from the prosternum up to the level of the top of the eye; the elytra with a white patch surrounding the scutellum on the bases of intervals 1–4, a broad white band just behind the middle between striæ 1–10, with its anterior edge deeply sinuate and the portion on interval 4 reduced and sometimes absent, a short white stripe on the apical fourth of interval 1, a few scales at the apex of interval 2, a row of single white scales on the apical fourth of interval 10, and a similar row of much narrower scales on the extreme margin; the lower surface fairly densely clothed with white scales, which are mostly narrow in the median area and broad laterally, being densest on the front portion of the prosternum, on the mesepimeron, mesosternal process, external apical angle of the metasternum, and on the extreme lateral margins of the abdomen; in the ♂ the scales in the centre of the metasternum are very long, narrowly lanceolate and obliquely raised, and those in the centre of the first ventral segment are setiform.

Head with the rostrum arising in the ♂ far above the middle of the eye, its upper surface being on a level with the top of the eye; in the ♀ it arises only slightly above the middle of the eye, its upper surface lying much below the top of the eye. *Rostrum*—♂, only a little longer than half the body, the basal half with a smooth central line and two irregular rows of punctures on each side, then a broad lateral furrow, bounded below by a distinct carina, the scrobe passing beneath the rostrum at the base and extending shortly beyond the antenna; in the ♀, slightly longer than the body, with the punctures and lateral furrow much less distinct. *Antennæ* inserted near (♂) or far behind (♀) the middle of the rostrum, the scape not reaching the eye; the funicle with joint 1 slightly shorter than 2, joint 3 distinctly longer than 4, and 4-7 subequal; the club slightly shorter than the three preceding joints, its first joint longer than the second. *Prothorax* distinctly broader than long (3 : 2), broadest at the base, the sides straight and gradually narrowed to the middle, then rounded and with a well-marked apical constriction, the apical margin truncate dorsally and sloping obliquely forwards behind the eye; the upper surface reticulately punctate throughout, sometimes with a trace of a median line. *Scutellum* subquadrate, with a few dark scales. *Elytra* with the lateral margins not sinuate, the apices separately rounded, the sutural impression deep and asymmetrical, the apical third of the suture with raised interlocking black bristles. *Legs* rather densely clothed with white setiform scales; the hind femora extending well beyond the elytra, and the mid femora with a fringe of hairs on the lower edge in both sexes; the tibiæ straight and with the basal sinuation very shallow. *Venter* of the ♂ with a large deep depression on segment 1, segment 2 with the posterior margin strongly angulate laterally, 3 and 4 flattened in the middle, and 5 excavate and bare in the middle, the posterior edge with a broad deep emargination and fringed with hairs, the outer angles being visible from above in the form of two conical prominences; in the ♀ segment 5 bears an oval median impression at the apex.

Length, 4–5·25 mm.; breadth, 2–2·5 mm.

SARAWAK: 4 ♂♂, 10 ♀♀, Kuching, v. 1909 (*J. E. A. Lewis*, type); 1 ♂, Puak, 30. iv. 1914 (*G. E. Bryant*).

22. BALANINUS IMITATOR, sp. n.

♂ ♀. Extremely similar to *B. analis*, sp. n., but differing as follows:—The apical white band on the prothorax does not extend above the middle of the eye, and the lateral basal patch hardly exceeds the fourth stria; on the elytra there is no apical row of scales on interval 10 or on the margin; in the middle of the metasternum of the ♂ the scales are small, flat and normal, and those on the first ventral segment are not setiform. The rostrum of the ♀ is shorter than the body (7 : 9 or 10), and the scrobe extends much further beyond the antenna in both sexes. The antennæ have joint 1 of the funicle slightly longer than 2, and the club is nearly as long as the four preceding joints. The sutural impression is rather shallower and the sutural bristles less raised. The hind femora only slightly exceed the apex of the elytra. The basal ventral impression in the ♂ is much shallower, the apical margin of segment 2 is quite straight and not angulate externally, segments 3 and 4 are transversely convex, and segment 5 is truncate at the apex, with a very shallow median impression and a few erect hairs on each side of it; the last ventral segment of the ♀ is simple and without any impression.

Length, 3–4 mm.; breadth, 1·6–2·4 mm.

SARAWAK: 7 ♂ ♂, 3 ♀ ♀ (1 ♀ on *Elæocarpus*), Quop, iii. 1914 (*G. E. Bryant*); 1 ♂, 1 ♀, Puak, v. 1914 (*G. E. Bryant*, type).

23. BALANINUS DECEPTOR, sp. n. (Pl. II. fig. 3.)

♂. Dull black, thinly clothed above with small black narrow scales or setæ, and with markings formed of broad white scales; the pronotum with a narrow transverse basal white patch on each side, almost reaching the mesepimeron externally and stria 5 internally; the elytra with a few white scales at the base of interval 1, a narrow transverse band at the base of intervals 2–4 (or 5), the portion on 2 being nearly twice as long as the rest, and a narrow sinuate macular white band behind the middle between striæ 1 and 9, the spot on interval 4 being absent and those on 2 and 9 a little longer than the others; the sternum with separated narrow white scales and with dense patches of broader scales on the precoxal area of the prosternum (emitting a band up the apical constriction to the level of the middle of the eye), on the mesepimeron, the mesosternal process, and the apical external angle of the metasternum; the venter more evenly clothed with broader white scales.

Very similar structurally to *P. analis*, sp. n., and apart from its larger size differing only in the following characters:—The scutellum has a broad and deep V-shaped incision on its anterior margin; the tooth on the femora is triangularly dilated at the base, and the mid femora entirely lack the fringe of hairs on the lower edge; the narrow scales on the metasternum are not hair-like and raised, but short, recumbent, and truncately fringed at the apex; the second ventral segment is not angulate externally, and the fifth is not excised at the apex, but bears a median depression almost concealed by a dense tuft of incurved hairs arising from a low elevation on each side of it; and the pygidium is much more exposed.

B. imitator, sp. n., differs in having the scutellum not or very faintly indented in front; the first joint of the funicle is slightly longer than the second, and the club is relatively longer; the hind femora are shorter and the femoral tooth is less dilated at the base; the basal ventral impression is much shallower and the structure of the fifth ventral segment is much more simple.

Length, 5·5 mm.; breadth, 3 mm.

SARAWAK: 2 ♂ ♂, Puak, iv–v. 1914 (*G. E. Bryant*).

24. BALANINUS COMMODUS, sp. n.

♂. Black, subnitid, thinly clothed above with recumbent blackish scales or setæ, and with markings formed of broader white scales; the prothorax with a subquadrate basal white patch on each side opposite intervals 4–7 of the elytra; the scutellum with a few minute white scales; the elytra with a few white scales at the base of interval 2, behind the middle a macular white patch on intervals 2 and 3, and another in line with it on intervals 7 and 8; the lower surface fairly closely covered with separated white scales and with the usual denser lateral patches of broader scales.

The structural characters as in *B. quincunx*, sp. n., except the following:—*Head* longitudinally convex, with the rostrum arising about the middle of the eye. *Rostrum* a little longer than half the body (5 : 9), the scrobe not exceeding the antenna. *Prothorax* less abruptly constricted in front and with feeble postocular lobes. *Scutellum* with a few white scales. *Venter* of ♂ with a shallow median impression on the anal segment, without any tufts of hair or apical fringe; the pygidium with short white setæ.

Length, 3·75 mm.; breadth, 2 mm.

SARAWAK: 1 ♂, Quop, iv. 1914 (*G. E. Bryant*).

25. BALANINUS GRYPUS, sp. n. (Pl. II. fig. 12.)

♂. Just like a very small specimen of *B. analis*, sp. n., but the white markings differ as follows: there is no vertical apical band on the prothorax and no apical lines on the elytra; the basal patches on the prothorax are broadly truncate internally (instead of tapering to a point), and the postmedian band on the elytra only reaches stria 8.

The structural characters agree also, except in the following respects: the rostrum is longer in proportion to the body (5 : 7); the funicle has joint 1 equal to 2; the prothorax is more elongate (9½–8), with the sides gently and more evenly rounded and scarcely constricted at the apex, the sculpturing being proportionately coarser; the mid femora have no fringe of hairs beneath; the second ventral segment is not angulate externally, and the fifth is quite simple and without any tufts of hairs; the pygidium is clothed with dense erect white setæ (in *B. analis* and *imitator* they are brown).

Length, 2·75 mm.; breadth, 1·5 mm.

SARAWAK: 1 ♂, Quop, 24. iii. 1914 (*G. E. Bryant*).

26. BALANINUS SHELFORDI, sp. n. (Pl. II. fig. 15.)

♀. Colour piceous brown, with dark brown scaling and markings of fawn and white scales; the prothorax with a narrow central stripe of transverse fawn scales, and on each side of the base a quadrate patch (occupying one-fourth the width and extending longitudinally nearly to the middle) formed of fawn scales which gradually turn to white at the base of the thorax, the inner anterior angle of the patch being produced as a narrow longitudinal stripe almost to the apex and with a few fawn scales just below its apical termination; the elytra with a complete fawn stripe on interval 1, and the following white markings: an oblong patch at the base of intervals 2 and 3, just behind the posterior line of this patch a small spot on intervals 3 and 5, another at the base of 7, and just behind the middle a band on intervals 2–4, which is broadest internally and narrows outwardly; the front portion of the prosternum, the sides of the metasternum, and the sides of segments 2–4 of the abdomen with fairly dense creamy white scales, those on the mesepimeron and metepisternum still denser.

Head with the front broader than the base of the rostrum, with a smooth central ridge and some fawn scaling on each side; the rostrum arising far below the middle of the eye, its lower surface being on a level with the lower margin of the eye. *Rostrum* shorter than the body (5 : 7), very smooth and shiny, almost impunctate even at the base, and without any lateral furrow or carina; the scrobe entirely lateral in position. *Antennæ* inserted far behind the middle of the rostrum, with the scape reaching the eye; the funicle with joint 1 only slightly longer than 2, joints 4–7 subequal; the club nearly as long as the four preceding joints and with joint 1 slightly longer than 2. *Prothorax* slightly broader than long (5 : 4), the sides parallel from the base to the middle, then rapidly narrowing, but scarcely constricted at the apex; the apical margin truncate dorsally and without postocular lobes; the upper surface with reticulate punctures and a low central carina. *Scutellum* slightly transverse, with a few pale fawn scales. *Elytra* with the apices separately rounded, the sutural impression rather shallow and quite symmetrical, and the apical half of the suture with raised interlocking bristles. *Legs* moderate, the hind femora slightly exceeding the apex of the elytra; the femoral teeth stout and sharp; the tibiæ with the basal sinuation shallow, the hind pair with the dorsal edge distinctly sinuate.

Length, 2·75 mm.; breadth, 1·5 mm.

SARAWAK: 1 ♀, on flowering tree, Kuching, 17. vii. 1900 (*R. Shelford*).

Type in the Oxford University Museum.

27. BALANINUS PUSIO, sp. n. (Pl. II. fig. 14.)

♀. Colour rather shiny black, thinly clothed above with narrow recumbent dark brown scales and with markings formed of broad white scales; the rostrum reddish brown; the pronotum with a transverse basal white patch on each side, almost touching the mesepimeron externally and extending as far as stria 3 internally; the elytra with a circum-scutellar white patch at the base of intervals 1 and 2, and a rather smaller patch slightly behind the middle on the same two intervals but not actually reaching the suture; the prosternum with dense white scales in front of the coxæ, but none at the sides; the rest of the lower surface with separated white scales, except on the mesepimeron and along the sides of the metasternum and abdomen, where the scales are dense.

Head with the forehead slightly broader than the base of the rostrum, the lower surface of which is on a level with the lower margin of the eye. *Rostrum* as long as the body, only slightly curved downwards in the apical third, very shiny and impunctate, even at the base where it is slightly compressed, and without any lateral furrow or carina; the scrobe entirely lateral and not exceeding the antenna. *Antennæ* inserted far behind the middle of the rostrum, with the scape reaching the eye; the funicle with joint 1 equal to 2 + 3 + 4, joint 2 half as long again as 3, joints 3–5 gradually diminishing in length, 6 and 7 each about equal to 4; the club a little longer than the three preceding joints, and with joint 1 slightly longer than 2. *Prothorax* rather broader than long (16 : 13), broadest at the base, with the sides moderately rounded, the apical constriction shallow, the apical margin slightly arcuate dorsally and without postocular lobes; the dorsal surface rather coarsely reticulate throughout. *Scutellum* transverse, and with only a few narrow brown scales. *Elytra* with the lateral margins straight, the apices jointly rounded, the basal sutural depression deep and asymmetrical, lying mainly on the right elytron, and the apical fourth of the suture with raised interlocked whitish bristles. *Legs* moderately long, thinly clothed with white setiform scales; the hind femora slightly exceeding the elytra, the tooth on the femora narrow; the tibiæ straight, with the basal sinuation shallow.

Length, 2 mm.; breadth, 1·2 mm.

SARAWAK: 1 ♀, Mt. Matang, 1000 ft., 11. ii. 1914 (*G. E. Bryant*).

28. BALANINUS DELICATULUS, sp. n. (Pl. II. fig. 13.)

♂ ♀. Colour rather shiny black, thinly clothed above with small dark brown scales and with patches of broad white scales; the rostrum blackish near the base and reddish brown externally; the pronotum with a transverse basal white patch on each side linking up with the mesosternal patch externally and reaching stria 3 internally; the scutellum with dense white scaling; the elytra with a broad white stripe on interval 1 reaching from the base nearly to the middle, and behind the middle a transverse white band extending outwardly to interval 4 or 5 and not quite reaching the suture; the lower surface clothed with separated small white scales and with dense patches of broader scales on the following areas: the antecoxal area of the prosternum, the whole of the mesepimeron, the posterior half of the metepisternum, and a stripe along the extreme lateral edge of the abdomen.

Head with the rostrum arising from the middle (♂) or below the middle (♀) of the eye; the forehead narrower than (♂) or about as broad as the base of the rostrum (♀). *Rostrum* shorter than the body in both sexes (♂, 8:13; ♀, 10:13), rather strongly curved downwards in the apical third; ♂, strongly striato-punctate in the basal half, with a smooth central line and a distinct furrow above the scrobe, which latter passes beneath the rostrum at the base; ♀, very finely punctate in the basal area, without any lateral furrow, and with the scrobe entirely lateral in position. *Antennæ* inserted at (♂) or far behind (♀) the middle of the rostrum; the funicle with joint 1 distinctly longer than 2, joints 3, 4, 6 and 7 subequal in length, 5 shorter; the club nearly as long as the four preceding joints, its first joint slightly longer than the second. *Prothorax* almost as long as broad, the sides nearly parallel from the base to the middle, thence roundly narrowed and shallowly constricted near the apex, the apical margin truncate dorsally and without postocular lobes; the upper surface distinctly more convex than usual, reticulately punctate and with a low median carina. *Scutellum* nearly circular. *Elytra* with the lateral margins not sinuate, the apices jointly rounded, the suture not impressed and with a row of slightly raised bristles on its apical third. *Legs* moderately long, thinly clothed with white setiform scales; the hind femora shortly exceeding the apex of the elytra, the tooth narrow; the tibiæ straight and with the basal sinuation distinct. *Venter* of ♂ with a few erect setæ near the apex of segment 5.

Length, 2·5–2·8 mm.; breadth, 1·25 mm.

SARAWAK: 1 ♂, Mt. Matang, 1000 ft. 13. ii. 1914 (*G. E. Bryant*—type); 1 ♂ 1 ♀, Kuching, 16. vii. 1900 (*R. Shelford*).

29. BALANINUS EUGENIÆ, sp. n.

♂ ♀. Ground-colour piceous black, the elytra and tibiæ dark red-brown: the pronotum with the usual narrow brown scales, mostly replaced by slightly broader pale scales on the basal third and isolated pale scales scattered over the rest of the surface; the elytra fairly densely clothed with broader fawn-coloured scales, variegated with darker patches formed of narrower brown scales; the sternum with separated whitish scales, but with dense fawn or orange-coloured scales at the sides of the meso- and metasternum, and a small patch of similar scales in the middle and on each side of the prosternum; the venter with fairly dense whitish scales.

Head with the rostrum arising from about the middle of the eye in both sexes. *Rostrum* about three-fourths the length of the body in both sexes, but much more strongly curved in the ♂, fairly strongly punctate in the basal section, with a smooth central line and a lateral furrow reaching the antenna, the scrobe passing beneath the base of the rostrum and not exceeding the antenna. *Antennæ* inserted well behind the middle of the rostrum in both sexes, the scape not quite reaching the eye; the funicle with joint 1 not or very slightly longer than 2, joint 3 a little longer than 4, 4–7 almost equal in length and about 1½ times as long as broad; the club about as long as the four preceding joints, joint 1 rather longer than 2, which is equal to 3. *Prothorax* rather broader than long, broadest at the base, the sides fairly strongly rounded, the apical constriction distinct, the apical margin truncate dorsally and with feeble postocular lobes; the upper surface with close reticulate punctation. *Scutellum* quadrate, covered with dense fawn scaling. *Elytra* with the lateral margins straight, the apices forming a joint shallow sinuation, the suture not impressed and without any raised setæ near the apex. *Legs* rather short, the hind femora only slightly exceeding the end of the elytra, the femoral teeth stout and sharp, the tibiæ evenly clothed with setiform scales. *Venter* with segment 1 longer than 2 behind the coxæ, segment 5 of ♂ sinuate at the apex and with a short tuft of whitish hairs on each side.

Length, 3·2–3·6 mm.; breadth, 1·6–1·8 mm.

SARAWAK: 1 ♂, Mt. Matang, ii. 1914, and 2 ♀ ♀, on *Eugenia*, Quop, 26. iii. 1914 (*G. E. Bryant*).

30. BALANINUS LONGICLAVIS, sp. n. (Pl. II. fig. 4.)

♂ ♀. Colour brownish black, rather thinly clothed with small narrow brown scales, sparsely intermingled with white ones, and the following markings formed of dense broad white scales: a small basal lateral patch on each side of the pronotum, the whole of the scutellum, a broad stripe on the basal third of interval 1 on the elytra, and a narrow line on the apical half of the suture; the lower surface also with brown and white scales, but broader than those above and the white ones greatly predominating, especially on the abdomen, and with the following patches of dense larger white scales: a small antecoxal one on the prosternum, a large vertical one on the side of the mesosternum, a smaller one at the external apical angle of the metasternum, and a small one at the side of the second ventral segment.

Head with the rostrum arising from above the middle of the eye, but its upper surface below the level of the top of the eye. *Rostrum* a little shorter than the body (9 : 10 or 7 : 8) in both sexes; ♂, moderately punctate in the basal area, with a smooth central line and a well-marked lateral furrow; ♀, with the punctures and furrow much less distinct; the scrobe not extending beyond the antennæ and passing beneath the base of the rostrum in the ♂, but not in the ♀. *Antennæ* inserted far behind the middle of the rostrum in both sexes, with the scape almost touching the eye; the funicle with joint 1 equal to 2 + 3, 3 slightly longer than 4, 4–6 short and subequal, 7 as long as 5 + 6 and more pubescent than the others: the club as long as the six preceding joints, with its two basal joints equal and unusually elongate, being distinctly longer than broad (4 : 3), and joint 2 markedly constricted in the basal half. *Prothorax* broader than long (13 : 10), broadest at the base, the sides moderately rounded in the ♀, less so in the ♂, the apical constriction being fairly distinct in the former and almost evanescent in the latter, the apical margin truncate dorsally and without any postocular lobes; the upper surface with shallow reticulate punctation throughout. *Scutellum* subquadrate. *Elytra* with the lateral margins not sinuate, the apices almost jointly rounded, the suture not impressed at the base and without any raised bristles near the apex. *Legs* moderately long, the hind femora scarcely exceeding the apex of the elytra; the tooth on the femora long and rather narrow, the basal sinuation of the tibiæ shallow and the dorsal edge straight. *Venter* of ♂ with an erect bristle on each side at the apex of the fifth segment.

Length, 3·5–4 mm.; breadth, 2–2·25 mm.

SARAWAK: 1 ♂ 1 ♀, Quop, iii. 1914, and 1 ♀, Puak, 4. v. 1914 (*G. E. Bryant*).

Distinguished by the remarkable elongation of the club, in which it resembles the otherwise dissimilar *B. sellatus*, sp. n. This character also occurs in a few African species.

31. BALANINUS SELLATUS, sp. n. (Pl. II. fig. 16.)

♀. Colour black, with a large discal patch on the elytra red-brown, the black areas mostly with small narrow dark scales, the brown area with broader fawn-coloured scales; the prothorax with a pentagonal patch of fawn scales in the middle of the base, not extending outwardly further than stria 2 of the elytra; the fawn patch on the elytra somewhat ill-defined, reaching from the base to beyond the middle and outwardly to about stria 4, though there are a few fawn scales just beyond this, and an indefinite elongate lateral patch extending from the margin to stria 8; the lower surface rather densely and uniformly clothed with yellowish and whitish scales.

Head with the forehead only slightly narrower than the base of the rostrum, which arises well below the middle of the eye, its lower surface being on a level with the lower margin of the eye. *Rostrum* as long as the body, slender, smooth, and almost impunctate at the base, and without any lateral furrow or carina; the scrobe entirely lateral and not exceeding the antenna. *Antennæ* situated far behind the middle of the rostrum, with the scape reaching the eye; the funicle with joint 1 as long as 2–5, joints 4–7 subequal in length, each a little shorter than 3, and 3 shorter than 2; the club very elongate, as long as the six preceding joints, with its first joint a trifle longer than the second, which is not constricted at the base. *Prothorax* broader than long (3 : 2), broadest at the base, rapidly narrowing thence to the apex, the sides being almost straight and the apical constriction obsolescent, the apical margin truncate dorsally and without any postocular lobes; the upper surface with shallow reticulate punctation and a mere trace of a raised central line. *Scutellum* punctiform. *Elytra* with the lateral margins not sinuate, the apices jointly rounded, the sutural impression not very deep and asymmetrical, being almost confined to the right elytron, and the suture with a row of raised bristles near the apex. *Legs* moderately long, but the hind femora scarcely exceeding the apex of the elytra; the tooth on the femora narrow and sharp, the basal sinuation of the tibiæ shallow, and only the front tibiæ with the dorsal edge slightly sinuate.

Length, 3 mm.; breadth, 1·5 mm.

SARAWAK: 1 ♀, Puak, 3. v. 1914 (*G. E. Bryant*).

32. BALANINUS DISCRETICOXIS, sp. n. (Pl. II. fig. 7.)

♀. Colour brownish black, subnitid, and apparently bare above, but really with minute dark recumbent setæ and markings of straw-yellow scales; the pronotum with a narrow median stripe (the scales longitudinal, broad at the base and narrow in front), a broader lateral stripe on each side extending from the base to the middle (scales oblique), and a spot on each side near the apex; the scutellum densely scaled; the elytra with a broad stripe on the basal third of interval 1 and extending partly on to 2, and about half-way between the end of this stripe and the apex a spot reaching from the middle of interval 2 to the middle of interval 3; the prosternum with an antecoxal patch that is whitish in the middle and yellow laterally; the mesosternum, metasternum, and the two basal abdominal segments each with a large patch of very dense straw-yellow scales.

Head coarsely punctate, bare, with the forehead distinctly broader than the base of the rostrum, which arises slightly below the middle of the eye. *Rostrum* as long as the body, very slender, almost of equal width throughout, very smooth and shiny, scarcely punctate even at the base, and without any lateral furrow or carina; the scrobe entirely lateral and not exceeding the antenna. *Antennæ* inserted far behind the middle of the rostrum, with the scape reaching the eye; the funicle with joint 1 equal to 2 + 3, and joints 3–7 very slightly and progressively diminishing in length; the club equal to the three preceding joints, with joint 1 slightly longer than 2. *Prothorax* almost as long as broad, the sides gently rounded, broadest about the middle, the apical constriction slight, the apical margin truncate dorsally and without postocular lobes; the upper surface with shallow reticulate punctures throughout. *Scutellum* almost circular. *Elytra* with the lateral margins straight, the apices jointly sinuate, the basal sutural impression short, shallow, and quite symmetrical, the apical third of the suture with raised dark bristles, and stria 9 remote from the base. *Legs* long, slender, and sparsely clothed with small recumbent white setæ; the hind femora shortly exceeding the apex of the elytra, the femoral teeth small and sharp; the front and hind tibiæ with the dorsal edge shallowly sinuate; the front coxæ distinctly separated.

Length, 3–3·5 mm.; breadth, 1·4–1·75 mm.

SARAWAK: 1 ♀ on flowers of *Vernonia arborea*, Mt. Matang, 1000 ft., 13. ii. 1914 (*G. E. Bryant*); 3 ♀, Quop, 21. iii. 1914 (*G. E. B.*).

A very distinct little species which differs from all other members of the genus known to me in having the front coxæ separated.

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25. On some new Fishes from near the West Coast of Lake Tanganyika. By G. A. BOULENGER, F.R.S., F.Z.S.

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(Text-figures 6–10.)

A few months ago I reported in these Proceedings* on a collection of Fishes made at Albertville by M. Dhont-De Bie, of the Belgian East African Expeditionary Force. On returning home in May last, the same gentleman has brought me further specimens from localities near but outside the great lake, among which were representatives of six undescribed species.

These Fishes are from three localities:—

(1) A ditch (marigot) along the Lukuga River: *Protopterus æthiopicus* Heck., *Clarias hilgendorfi* Blgr. (previously known from Lake Rukwa), *Auchenoglanis occidentalis* C. & V., *Anabas ctenotis*, sp. n., and *Mastacembelus tæniatus* Blgr.

(2) Tumbwe, a village S.W. of the Kalemie River, on a small stream flowing into the Niemba River, a tributary of the Lukuga: *Labeo dhonti*, sp. n., *Barbus euchilus*, sp. n., *B. miochilus*, sp. n., *B. holotænia* Blgr.

(3) Kabeke, a village 30 miles south of Tumbwe, on the Niemba River: *Allabenchelys dhonti*, sp. n., *Amphilius platychir* Gthr., *Phractura lukugæ*, sp. n., an association very suggestive, so far as genera are concerned, of the rivers of South Cameroon, whence the two first known representatives of the genus *Allabenchelys* Blgr. were described, and where several *Amphilius* Gthr., and *Phractura* Blgr., are at home.

It is remarkable that no members of the family *Cichlidæ*, which form the great majority in the Tanganyika Fish-fauna, should have been collected in these three localities. *Characinidæ* are also absent.

Descriptions of the new Species.

LABEO DHONTI.

Body feebly compressed, its depth 5 to $5\frac{2}{3}$ times in total length. Head 4 to $4\frac{1}{3}$ times in total length, its width $\frac{2}{3}$ its length; snout rounded or very obtusely pointed, strongly projecting, with a curved transverse groove above, its length less than half that of head; eye small, supero-lateral, 5 to $5\frac{1}{2}$ times in length of head; interorbital width $\frac{2}{5}$ length of head; width of mouth (with lips) $\frac{2}{5}$ to $\frac{1}{2}$ length of head; lips strongly developed, upper straight-edged, lower more or less expanded and bordered in front by a fringe of papillæ, the posterior border strongly festooned; inner surface of lips with small papillæ forming numerous transverse plicæ: rostral flap large, completely detached on the sides, its edge feebly festooned; nuptial tubercles or their scars on the upper surface of the snout. Dorsal III 10–11, equally distant from nostrils and from root of caudal, upper edge concave, last simple ray as long or a little longer than head. Anal III 5, reaching root of caudal or not. Pectoral as long as or a little shorter than head, not reaching ventral, the first ray of which falls below fourth branched ray of dorsal. Caudal deeply emarginate, crescentic when fully spread out. Caudal peduncle $1\frac{1}{2}$ times as long as deep. Scales 35–36 $\frac{5\frac{1}{2}}{6\frac{1}{2}-7\frac{1}{2}}$, $3\frac{1}{2}$ between lateral line and ventral, 12 (exceptionally 14) round caudal peduncle. Dark olive above, white beneath; a more or less distinct dark lateral band; sometimes ending in a black spot.

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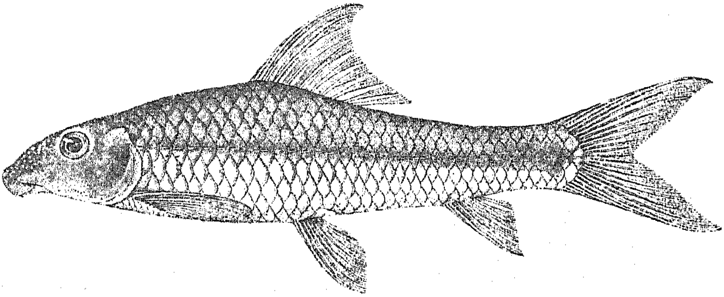
* *Cf.* P. Z. S. 1919, p. 17.

Text-figure 6.



Labeo dhonti.

Total length 115 mm.

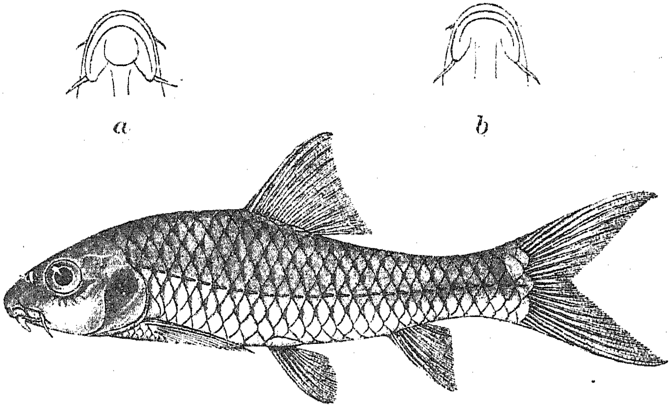
Six specimens from Tumbwe.

Distinguished from *L. cylindricus* Peters by a more elongate body and a lower number of scales round the caudal peduncle.

Barbus euchilus.

Depth of body 4 times in total length, length of head $3\frac{1}{2}$ times. Snout rounded, $\frac{1}{3}$ length of head; eye 4 times in length of head, interorbital width $3\frac{1}{3}$ times; mouth inferior, its width $3\frac{1}{2}$ times in length of head; both lips much developed, the lower with a rounded median lobe; two barbels on each side, anterior $\frac{2}{5}$ diameter of eye, posterior $\frac{3}{5}$. Dorsal IV 10, equally distant from eye and from root of caudal; border concave; last simple ray not enlarged, articulate in its distal half, smooth, $\frac{4}{5}$ length of head. Anal III 5, not reaching caudal. Pectoral $\frac{3}{4}$ length of head, not reaching ventral; base of latter below middle of dorsal. Caudal peduncle $1\frac{1}{2}$ times as long as deep. Scales longitudinally striated, $26\frac{4\frac{1}{2}}{5}$, 2 between lateral line and ventral, 12 round caudal peduncle. Brown above, whitish beneath; a large dark brown spot on the gill-cover.

Text-figure 7.



Barbus euchilus, with lower view of anterior part of head in same (*a*) and in *B. miochilus* (*b*).

Total length 80 mm.

A single specimen from Tumbwe.

Very closely allied to *B. caudovittatus* Blgr., from the Ubanghi, but eye smaller and lips more developed.

BARBUS MIOCHILUS.

Depth of body equal to length of head, 4 times in total length. Snout rounded, $\frac{1}{3}$ length of head; eye 4 times in length of head, interorbital width 3 times; mouth inferior, with sharpish edge, its width $3\frac{1}{2}$ times in length of head; lips moderate, lower restricted to the sides; two barbels on each side, anterior $\frac{1}{3}$ diameter of eye, posterior $\frac{1}{2}$ to $\frac{3}{5}$. Dorsal IV 10, equally distant from centre of eye and from root of caudal: border concave; last simple ray not enlarged, articulated nearly to the base, smooth, a little shorter than head. Anal III 5, not reaching caudal. Pectoral $\frac{3}{4}$ length of head, not reaching ventral; base of latter below middle of dorsal. Caudal peduncle $1\frac{1}{3}$ to $1\frac{1}{2}$ times as long as deep. Scales longitudinally striated, 25–26 $\frac{4\frac{1}{2}}{4\frac{1}{2}}$, 2 between lateral line and ventral, 12 round caudal peduncle. Brown above, whitish beneath; a large dark-brown spot on the gill-cover. Male with very small round nuptial tubercles on the snout and larger ones on the lower surface of the head.

Total length 85 mm.

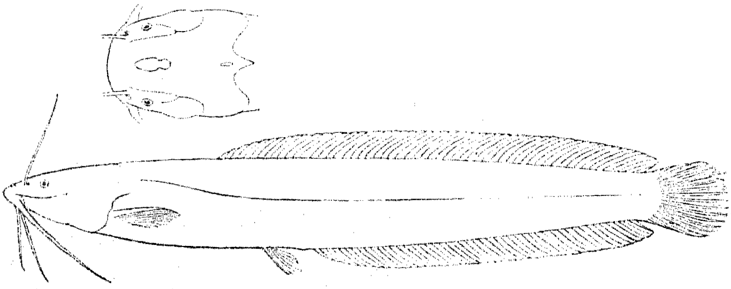
Four specimens from Tumbwe.

Closely resembles the preceding, but distinguished by the character of the lips and the shape of the mouth.

Allabenchelys dhonti.

Depth of body 7 to 8 times in total length, length of head $4\frac{1}{2}$ to 5 times. Head $1\frac{1}{4}$ to $1\frac{1}{3}$ times as long as broad, smooth above, the bony casque, in the middle of the head, $\frac{2}{5}$ to $\frac{1}{2}$ width of head; occipital process acutely pointed; a rather large frontal fontanelle; occipital fontanelle small, in advance of occipital process; eye very small, 3 times in length of snout, 6 to 7 times in interorbital width, which is $1\frac{3}{4}$ to $2\frac{1}{4}$ times in length of head; band of præmaxillary teeth 4 to 5 times as long as broad; vomerine teeth granular, forming a crescentic band which is a little narrower than the præmaxillary band: nasal barbel $\frac{3}{5}$ to $\frac{2}{3}$ length of head; maxillary barbel as long as or a little shorter than head, not reaching middle of pectoral fin; outer mandibular barbel $\frac{2}{3}$ to $\frac{3}{4}$ length of head, inner $\frac{1}{2}$ to $\frac{3}{5}$. Gill-rakers moderately long, 10 to 12 on anterior arch. Clavicles hidden under the skin. Dorsal 55–60, its distance from occipital process $\frac{1}{2}$ to $\frac{3}{5}$ length of head. Anal 50–53. Both dorsal and anal narrowly separated from caudal. Pectoral $\frac{2}{5}$ to $\frac{1}{2}$ length of head, its spine strongly serrated on outer side and smooth on inner, and $\frac{1}{2}$ to $\frac{2}{3}$ the length of the fin. Ventral $1\frac{1}{3}$ to $1\frac{1}{2}$ times as distant from root of caudal as from end of snout. Caudal $\frac{1}{2}$ to $\frac{3}{5}$ length of head. Dark brown above, whitish beneath.

Text-figure 8.



Ailabenchelys dhonti.

Total length 165 mm.

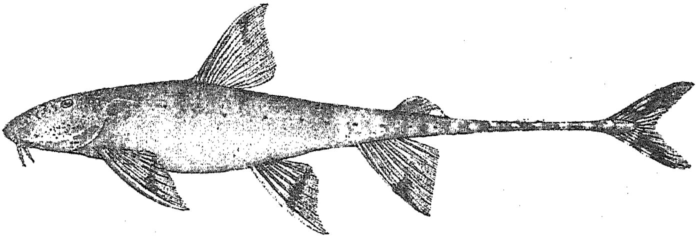
10 specimens from Kabeke.

Phractura lukugæ.

Depth of body $6\frac{1}{2}$ times in total length, length of head $5\frac{2}{3}$ times. Head $1\frac{1}{3}$ times as long as broad, feebly rugose above: snout half length of head, obtusely pointed, projecting beyond mouth; space between nostrils a little nearer eye than end of snout; eye very small, on upper surface of head, 8 diameters in length of head, 2 in interorbital width; lips and barbels covered with large round papillæ beneath; maxillary barbel $\frac{1}{3}$ length of head, outer mandibular a little shorter, inner mandibular $\frac{1}{5}$.

Occipital process long and very narrow, not reaching interneural shield. Dorsal I 6, twice as distant from base of caudal as from end of snout; second dorsal a little nearer first than root of caudal. Anal II 7. Pectoral as long as head, longer than ventral; latter not reaching anal. Caudal with crescentic notch. 24 dorsal and 19 ventral scutes, the last 5 united on caudal peduncle, which is $\frac{1}{3}$ of the total length. Pale yellowish above, white beneath; three ill-defined darker bars across the body and dark annuli on the caudal peduncle; pectorals, ventrals, and anal with rather indistinct dusky cross-bars; black variegations on each lobe of the caudal.

Text-figure 9.



Phractura lukugæ.

Total length 90 mm.

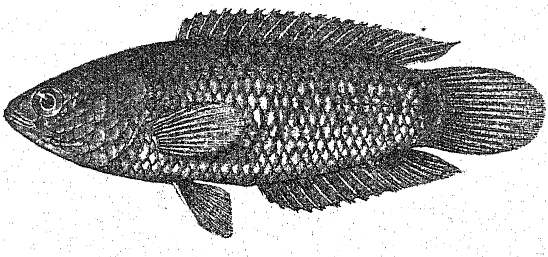
A single specimen from Kabeke.

This species is intermediate between *P. bovii* Perugia and *P. lindica* Blgr., from the Congo.

ANABAS CTENOTIS.

Depth of body equal to length of head, 3 times in total length. Snout rounded, a little shorter than eye, which is 4 times in length of head and $1\frac{1}{5}$ times in interorbital width; maxillary extending to below anterior fourth of eye; no palatine teeth; præorbital, præoperculum, and interoperculum entire; suboperculum

Text-figure 10.



Anabas ctenotis.

strongly denticulate; 8 to 10 strong, subequal serræ above and 5 or 6 below opercular notch. Dorsal XV–XVI 8; last spine longest, $\frac{1}{3}$ length of head; longest soft rays $\frac{1}{2}$ length of head. Anal X 7–8. Pectoral $\frac{2}{3}$ length of head. Ventral reaching or nearly reaching anal. Caudal peduncle very short, nearly as long as eye. Scales rugose, strongly ctenoid, $27\frac{3}{8\text{–}9}$; lateral lines $\frac{13\text{–}14}{7\text{–}8}$. Brown, with small darker spots; fins dark brown, caudal blackish at the base.

Total length 70 mm.

Two specimens from a ditch near the Lukuga River.

This species is very near *A. nanus* Gthr., from which it is distinguished by the denticulation of the gill-cover, the different anal fin-formula, and the shorter ventral fins.

26. The Radula of the Mitridæ.

By the Rev. A. H. Cooke, Sc.D., F.Z.S.

[Received October 16, 1919: Read November 18, 1919.]

(Text-figures 1–18.)

Fifty years have passed since F. H. Troschel published his great work on the radulæ of Mollusca (**11**), and, during the interval, the number of Mitridæ whose radulæ have been investigated may be counted on the fingers of one hand. From one cause or another, Troschel's work on the group contained some serious errors of misstatement, which have been copied into the subsequent Manuals dealing with the Mollusca, *e. g.*, those of P. Fischer (**1**) and Tryon (**12**). Troschel figured, as belonging to *Imbricaria*, a radula closely akin to that of *Vasum*, and placed the subgenus close to the Turbinellidæ; he held that *Strigatella* had a radula whose form differed widely from that of the typical Mitridæ, and was closely allied to that of *Turricula* (now *Vexillum* Bolt.), while the true form of the *Vexillum* radula was imperfectly described by him.

The recent acquisition, by the British Museum (Natural History), of the vast collection of radulæ formed by the late Prof. H. M. Gwatkin, enables fresh light to be thrown on this and other groups, while the results can be checked, in part, by the collections which he gave, during his lifetime, to Cambridge and other Universities.

Troschel figured and described 13 species of Mitridæ (*Cylindra* 1, *Mitra* proper 5, *Imbricaria* 1, *Strigatella* 2, *Turricula* (*Vexillum*) 4: *Volutomitra* is now more correctly placed with the Volutidæ. The Gwatkin Collection contains 14 *Vexillum* and 37 belonging to other groups, of which 51 only 4 were known to Troschel, and nearly all are new to Science.

In *Mitra* proper the radula is remarkably broad in proportion to its length, a feature due to the extreme width of the laterals. For instance, in adult specimens, we have :—

adusta Lam.	Length in mm.		5·0;	breadth in mm.		1·5.
cardinalis Gmel.	,,	,,	5·0	,,	,,	1·2.
digitalis Chem.	,,	,,	5·0	,,	,,	1·4.
episcopalis L.	,,	,,	7·0	,,	,,	2·0.
glabra Swains.	,,	,,	6·5	,,	,,	1·6.
papalis L.	,,	,,	5·0	,,	,,	1·0.

The number of rows of teeth varies :—

adusta (full-grown)	has	76+	nascent	rows.
,, (young)	,,	64	,,	,,
cardinalis	,,	61	,,	,,
,, (another spec.)	,,	67	,,	,,

cucumerina	has	47+	nascent	rows.
digitalis	,,	72	,,	,,
episcopalis	,,	71	,,	,,
ferruginea	,,	81	,,	,,
fulva	,,	74	,,	,,
glabra	,,	106	,,	,,
papalis	,,	70	,,	,,

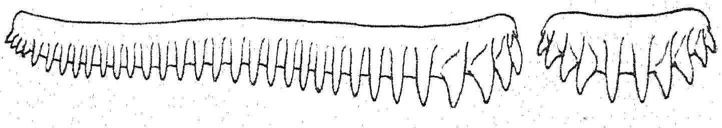
In many genera of rhachiglossate Mollusca, and particularly in the Thaidæ and allied groups, the form of the laterals is nearly constant, and affords little help in subdivision and classification; the shape of the rhachidian is the determining factor. In the Mitridæ the reverse is the case, for while the rhachidian tooth varies considerably in shape, the modifications of the laterals are of great importance, and appear to be of equal or even superior value in estimating the relationships of allied groups and species. Thus, *Vexillum* is at once separated from all other forms of *Mitra* by its single-hooked laterals.

Similar, though not so wide divergencies in the laterals form a basis for classification within the various groups. In this respect, the Mitridæ fall into line with the allied genera *Fusinus*, *Fasciolaria*, *Latirus*, and *Peristernia*, in all of which the laterals, rather than the rhachidian tooth, supply the best evidence for classification. In these four genera, the rhachidian is so much reduced in size that it has practically lost those characteristics which can be employed to distinguish one group from another. The Mitridæ have not quite reached this point of development, or, as it might be called, of degradation, but the rhachidian is small in proportion to the rest of the lingual apparatus.

Group 1. Mitra Martyn.

Rhachidian 6–11-cusped on a squarish or oblong framework: *laterals* long rake-shaped, multicuspid, the interior cusps inclining slightly inward, cusps 2, 3, or 4 slightly the largest.

Text-figure 1.



Lateral and rhachidian tooth of *Mitra adusta* Lam.

Section (*a*). *Mitra* proper.—*Rhachidian* with 8-11 deeply rooted sharp cusps, the outermost of which lie obscurely behind the others.

1. *M. adusta* Lam. Rotuma. *Rhachidian* 10-cusped, the 6 inner cusps nearly equal, the 2 outer on each side smaller, and lying somewhat behind and below the others; base nearly straight,

framework of the tooth rather narrow: *laterals* with 30–32 cusps, deeply rooted, gradually diminishing to the outside.

Troschel's figure of the rhachidian is quite wrong.

2. *M. cardinalis* Gmel. Samoa. *Rhachidian* 8-cusped, cusps rather short, the 6 interior about equal, the 2 exterior smaller and withdrawn; base very slightly curved: *laterals* with 13–15 cusps, diminishing to mere serrations outside, inside 6 or 7 deeply rooted. Another specimen from Torres Strait agrees in essentials.

3. *M. cucumerina* Lam. Samoa. *Rhachidian* 8-cusped, with two curious projecting side-pieces, cusps nearly equal, deeply rooted; framework of tooth narrow, base slightly rounded below: *laterals* about 15, diminishing outwardly, inside 2 smaller, inclining inwards.

4. *M. digitalis* Chem. Samoa. *Rhachidian* 10-cusped, cusps rather long, deeply rooted, the 6 interior cusps more or less equal, 4 exterior smaller and projecting sideways; base straight, framework of tooth deeper than in *cucumerina*: *laterals* with 28–30 denticles, gradually diminishing to the outward end of the tooth, all deeply rooted; interior 3 or 4 inclining inwards.

In another specimen (also from Samoa) the forward end of the radula tapers away almost to nothing, so that both rhachidian and laterals are gradually much reduced in size.

5. *M. fulva* Swains. Fiji. *Rhachidian* 8-cusped, cusps rather long and narrow, deeply rooted, the 4 central the largest, outer 2 on each side more stumpy; framework of tooth rather narrow, base straight: *laterals* with 20–21 cusps, gradually diminishing right to the end, interior 3 or 4 inclined inwards.

6. *M. glabra* Swains. Tasmania. *Rhachidian* 8-cusped, moderately long, but shorter than in *fulva*, central 6 nearly equal, the 2 outside shorter and withdrawn; framework narrow, base straight: *laterals* with 30–32 cusps, all deeply rooted, gradually diminishing to the end; framework rather narrow.

7. *M. rhodia* Reeve. Port Jackson. *Rhachidian* 5-cusped on a peculiarly shaped squarish framework, cusps very deeply rooted, the 3 interior the largest, numbers 2 and 4 set at a slight angle to the central cusp; base straight, upper margin curved: *laterals* with 15-16 cusps, very deeply rooted, not very sharp, gradually diminishing almost to the end, extreme end bare, inside 3 or 4 cusps inclining inwards; framework of tooth nearly straight.

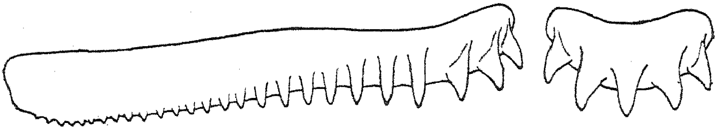
8. *M. scutulata* Chem. E. Indies. *Rhachidian* 8-cusped on a broadish-oblong framework, cusps deeply rooted, somewhat broad and blunt, projecting well above the upper margin, the 4 central the longest; base straight: *laterals* with 26–28 cusps, gradually diminishing to mere points, which continue nearly to the end, about half deeply rooted, cusps 3, 4, 5 (from inside) the largest.

9. *M. stephanucha* Melv. Karachi. The specimen is badly mounted and can scarcely be seen, but the radula apparently belongs to this group. *Rhachidian* with 3 fairly long cusps, deeply rooted, these are flanked by 2 or 3 smaller cusps on each side: *laterals* many-cusped, cusps rapidly diminishing in size.

In all the above species the characteristic orange colour of the rhachidian is distributed all over the framework.

Section (*b*). *Papalaria* Dall.—*Rhachidian* with 7–9 cusps; cusps short, triangular, the external set at an angle to those in the centre.

Text-figure 2.



Lateral and rhachidian tooth of *Mitra* (*Papalaria*) *papalis* L.

1. *M. episcopalis* L. Funafuti. *Rhachidian* 8–9-cusped, cusps stout and broad, set on an arching curve of the upper margin, deeply rooted, base nearly straight: *laterals* with 20–22 cusps, gradually diminishing to mere serrations at the end, inside 11 deeply rooted, the 3 innermost inclining inwards.

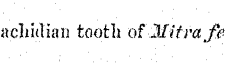
In an immature specimen from S. Pacific (Cambridge) there are only 5 cusps on the rhachidian, the central much the thickest and longest. Troschel's figure is very poor.

2. *M. papalis* L. S. Pacific. *Rhachidian* 7-cusped, the external 2 being obscure and withdrawn; interior 5 nearly equal, central slightly the largest, all set on a curved thickening of the upper half of the framework, base slightly curved: *laterals* with 28–30 cusps, the interior 10–11 the largest, then diminishing to mere serrations, which continue to the end.

In both these species the 4 central cusps seem to be mounted on a superposed plate, which is coloured deep orange, the rest of the framework is colourless or very light yellow.

Section (*c*) of *M. ferruginea*.—*Rhachidian* cusps of equal size, narrow, none projecting at the sides or withdrawn behind the others.

Text-figure 3.



Lateral and rhachidian tooth of *Mitra ferruginea* Lam.

M. ferruginea Lam. Samoa. *Rhachidian* 6-cusped, cusps rather thick and stumpy, mass of the tooth rather deep, the 1st and 6th cusps descend perpendicularly at the sides, and there are no obscure side cusps or pieces; base very slightly arched: *laterals* 15–17, crowded together, the 5 inside much the largest; about half are deeply rooted, the rest diminish into serrations which continue to the end.

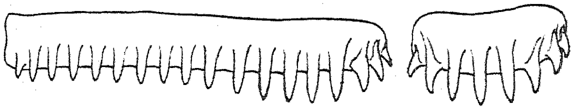
The complete absence of any small cusps on the side of the rhachidian, which often makes it difficult to count their actual number, seems to justify the creation of a separate section for this species.

Group 2. Subgenus Dibaphus Philippi.

Rhachidian closely allied to that of *Mitra* proper, 8–9-cusped: *laterals* multicuspid as in *Mitra*.

D. edentulus Reeve. Polynesia. *Rhachidian* with 8–9 deeply rooted sharpish cusps, projecting well beyond the upper margin, the 5 central the longest; upper margin slightly curved, base slightly arched: *laterals* with 19–21 deeply rooted sharp cusps, set well apart, gradually diminishing to the outer end of the framework.

Text-figure 4.



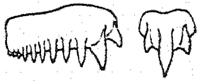
Lateral and rhachidian tooth of *Dibaphus edentulus* Reeve.

A specimen from Mauritius has 9 cusps on the rhachidian and 18–19 on the laterals, another (Cambridge) from Mauritius has 43 + nascent rows.

Group (3) of *coriacea*.

M. coriacea Reeve. S. Pacific. *Rhachidian* 3-cusped, cusps thin and sharp, the central 3 times as long as the others, all projecting well beyond the upper margin, which is much curved, sloping sharply away from the central cusp; on the outer sides of the central mass are two lateral projections, like broad denticles; base slightly curved: *laterals* with rather a deep framework, set with 10–12 sharp denticles along a straight upper margin, about half of these are deeply rooted, they continue to the end, leaving no bare space; a small prow-like projection stands out from the interior edge of the lateral, pointing to the similar projection on the rhachidian.

Text-figure 5.



Lateral and rhachidian tooth of *Mitra coriacea* Reeve.

In this group, of which *coriacea* is the single known representative, the laterals are fairly typical, but the singular form of the rhachidian separates it off.

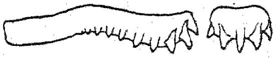
Group 4. Subgenus STRIGATELLA Swainson.

This group shows:—

acuminata S.	60 + nasc.	rows of	teeth,	6	cusps on	rhachidian.
astricta	55	,,	,,	7	,,	,,
columbellæformis	75	,,	,,	5 +	,,	,,
limbifera	86	,,	,,	7	,,	,,
litterata	76, 80, 86, 87	,,	,,	7	,,	,,
luctuosa	81	,,	,,	7	,,	,,
pellis serpentis	52	,,	,,	7	,,	,,
planilirata	95	,,	,,	6	,,	,,
tristis	74	,,	,,	8	,,	,,

Rhachidian tooth shaped more or less as in *Mitra* proper, with 5–8 narrow cusps, sharp or blunt, short or prolonged, the two external somewhat withdrawn and obscure: *laterals* comb-shaped, the inner half of the framework more or less arched, the outer half straight, with a marked "break" or division between the two halves; inner half set with well-marked smallish cusps (the inner 3 or 4 incline slightly inwards), which become mere points or fade away altogether on the outer half; extreme end usually quite bare.

Text-figure 6.



Lateral and rhachidian tooth of *Strigatella litterata* Lam.

1. *S. acuminata* Swains. Rotuma. *Rhachidian* 6-cusped, the 4 central cusps deeply rooted, the 2 outer small, and lying at the side and somewhat behind; cusps rather thick, projecting well above the upper margin: *laterals* with 7–8 well formed, deeply rooted cusps, these rapidly diminish to mere serrations or points; there are about 10 of these, reaching almost to the end; the "break" not very prominent.

An immature specimen at Cambridge, also from Rotuma, has 5 cusps on the rhachidian, the central the longest, and fewer cusps on the laterals.

2. *S. astricta* Reeve. Maui. *Rhachidian* 7-cusped, the 2 outer obscure, lying as in *acuminata*, central the largest, all deeply rooted, not projecting far beyond the margin; base scarcely arched: *laterals* with 6 inner denticles, conspicuous, deeply rooted, then suddenly mere serrations, or the rest quite bare; 4th cusp from inside the largest; "break" conspicuous.

3. *S. columbellæformis* Reeve. Rotuma. *Rhachidian* squarish, 5-cusped, with an additional obscure cusp or projection at the sides, cusps very deeply cut and chiselled out of the mass, tips blunt, scarcely projecting above the margin: *laterals* with 6–7

strong deeply rooted denticles, then a few serrations or points, and finally blank, denticles 3 and 4 much the strongest; "break" very pronounced.

4. *S. limbifera* Lam. Durban. *Rhachidian* 7-cusped on a squarish-oblong base, cusps deeply rooted, short and stumpy, scarcely projecting above the upper margin; base straight or very slightly rounded: *laterals* with 9–10 short thick denticles which rapidly diminish to mere points, then a long bare space, almost equal to that occupied by denticles; "break" well marked.

5. *S. litterata* Lam. Andamans. *Rhachidian* 7-cusped, cusps deeply rooted, the 2 exterior very small, and lying behind, interior 3 equal, projecting considerably beyond the upper margin, next two rather smaller, all rather thick and stumpy; base quite straight: *laterals* with 8–9 short, stout, deeply rooted denticles, rapidly diminishing to points or serrations, end bare: "break" sharply marked.

Specimens from Hilo, Hawaii, and from Scottburgh, Natal, correspond in essentials, but have rather more (11–13) denticles on the laterals. One from Isipingo exhibits the 2 obscure exterior cusps on the rhachidian much more plainly, while the 5 interior are of about equal length.

6. *S. luctuosa* A. Ad. Durban. This might well be a specimen of *litterata*, except that the cusps, both in *rhachidian* and *laterals*, are sharper, and further apart; there are 7–8 cusps only in the laterals, and beyond them the bare space is very long.

7. *S. pellis serpentis* Reeve. Mauritius. Radula small; *rhachidian* 7-cusped, cusps short, rather blunt, deeply rooted, projecting beyond the upper margin, central the thickest and longest; base straight: *laterals* with 6 large cusps, rather sharply triangular, some distance apart, then a bare space to the end, the first two only incline slightly inwards; "break" not very strongly marked.

This species, in the shape of the lateral cusps, stands rather apart from the others.

8. *S. planilirata* Reeve. Suez. *Rhachidian* 6-cusped, cusps somewhat sharp and narrow, deeply rooted, tips not projecting far beyond the margin; base straight: *laterals* with 7–8 deeply rooted cusps, rather near together, gradually diminishing to points, bare space quite considerable; "break" not very marked.

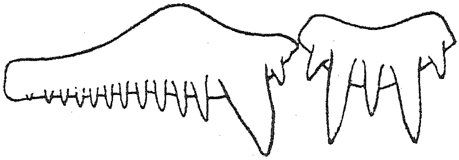
9. *S. tristis* Sowb. Panama. *Rhachidian* with the upper margin produced at the angles into two curious horns, cusps 8, deeply rooted, the 2 exterior scarcely visible, central 4 the largest, tips scarcely projecting beyond the upper margin; base wavy-straight: *laterals* with 6–7 strong blunt cusps, very deeply rooted on the arched portion, then rapidly diminishing to points, which continue right to the end, no bare part.

One would expect this species, the only Neotropical representative of the subgenus whose radula is known, to exhibit differences in structure from the rest, and it does so.

Group 5. Subgenus IMBRICARIA Schumacher.

Rhachidian with 2 large and 2–3 small cusps: *laterals* with one or more cusps considerably developed, remainder either numerous or few and degraded.

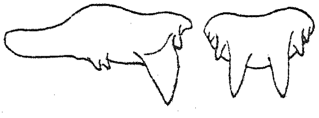
Text-figure 7.



Lateral and rhachidian tooth of *Imbricaria marmorata* Swains.

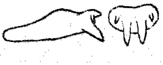
1. *I. marmorata* Swains. Upolu. *Rhachidian* 5-cusped, all sharp and projecting beyond the upper margin, the central small, flanked on each side by a very large cusp, outside these one small cusp, with sometimes a trace of a second; all these are set upon a thick plate, the base of which is somewhat angled in the middle; *laterals* with 12–14 cusps, the third from the inside much the largest, inside this are 1 or 2 small denticles, all these incline slightly inwards; outside the big cusps are 9–11 upright, sharp, narrow denticles, diminishing to mere points which continue to the end of the framework; in the central portion of the lower side of the framework is a roughly triangular "false keel"; the framework itself narrows towards both ends, becoming almost pointed on the inner side.

Text-figure 8.



Lateral and rhachidian tooth of *Imbricaria ossea* Pease.

Text-figure 9.



Lateral and rhachidian tooth of *Imbricaria olivæformis* Sowb.

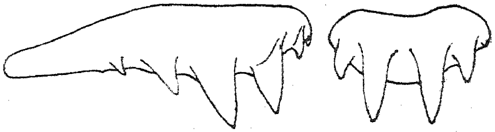
2. *I. ossea* Pease. Samoa. *Rhachidian* with a roughly triangular framework, nearly all of which is occupied by 2 long prominent sharp cusps, whose roots are carried through to the base, these are flanked on each side by 2–3 wrinkles rather than cusps, their points not projecting above the slope of the upper margin: *laterals* with the second cusp enormously developed,

pointing inwards, at its inner base is one sharp almost adherent denticle, outside 4–5 very small denticles, which diminish to mere points, all inclining sharply inward, but for the big denticle, the appearance of the tooth is degraded; "false keel" well marked and deep.

In a more mature specimen from Society Is., the flanking cusps on the rhachidian are better marked; in the laterals there are only 2–3 denticles outside the big one, close together on one side, further apart on the other; the framework is sharply pointed towards the rhachidian, bluntly pointed on the outside.

3. *I. olivæformis* Sowb. S. Pacific. *Rhachidian* with two large, sharply pointed cusps, projecting well beyond a curving upper margin, flanked on each side by a single small denticle standing out against the mass of the tooth, its apex not reaching the curve of the upper margin, sides of the tooth continue this curve, base nearly straight: *laterals* quite bare, save for one large cusp, inclining inwards, no trace of further denticulations; upper margin straight, lower curved, framework pointed towards the rhachidian; general appearance very degraded.

Text-figure 10.



Lateral and rhachidian tooth of *Imbricaria punctata* Swains.

4. *I. punctata* Swains. W. Maui. *Rhachidian* 4-cusped, flanked by wrinkles, the 2 large inner cusps deeply rooted, with no intervening central cusp; the 2 side cusps larger than in *marmorata*: the superposed plate from which the cusps spring is extended angularly at the sides: *laterals* 5–6-cusped, the inside 2 small, then 2 large ones, then one or two much smaller, diminishing rapidly, all cusps inclining sharply inwards; a rather shallow but well marked "false keel"; general appearance degraded.

This species is often regarded as identical with *ossea* Reeve, and the radula is not against this view.

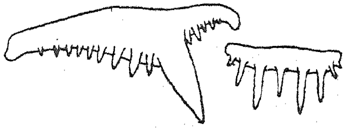
Group (6) of *flammigera* Reeve.

Rhachidian 7–8-cusped on a narrow framework: *laterals* multicuspid, cusps about 11–15, one or two of exaggerated size; framework narrowed prow-like inside, produced below into a "false keel."

1. *M. flammigera* Reeve. Durban. *Rhachidian* 8–9-cusped, cusps narrow and sharp, set on the margin of a very narrow framework, the 5 interior alternately larger and shorter, externals mere

serrations; base straight: *laterals* with one of the denticles (in place of the 3rd or 4th) immensely exaggerated in size, and inclining inward, forming a separation between the two parts of the tooth; the inner part is narrow, produced like the prow of a boat, and carries 3–4 fine needle-like denticles or serræ close to the big denticle, while the tip is bare; on the outer part small denticles (about 9) mount up towards the big denticle; they are set apart from one another, gradually diminishing and leaving the external portion of the margin quite bare.

Text-figure 11.

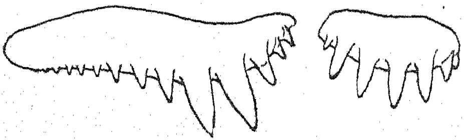


Lateral and rhachidian tooth of *Mitra flammigera* Reeve.

In another specimen (also from Durban), the *rhachidian* is smaller and narrower, and has a rather thicker framework; the cusps are very irregular, 2, 3, or 4 in number, of various sizes and dispositions in different rows: the *laterals* are very faintly serrated just inside the big denticle, which, on one side only of the whole radula, is bifurcated (and in some cases trifurcated) like a lobster's claw.

2. *M. interlirata* Reeve. Durban. *Rhachidian* 7-cusped, cusps shaped as in *flammigera*, the 3 interior much the largest, the central the shortest of the three; base narrow, nearly straight; upper margin slightly curved: in the *laterals* the big denticle is rather longer than in *flammigera*; there are 4–5 minute denticles or serræ on the interior part of the margin; on the exterior side of the big denticle are 7–8 small denticles, end of framework bare*.

Text-figure 12.



Lateral and rhachidian tooth of *Mitra pretiosa* Reeve, Durban.

3. *M. pretiosa* Reeve. Suez. *Rhachidian* 7–8-cusped, cusps sharp and projecting far beyond the upper margin, the 4 interior much the largest, all deeply rooted; base straight: *laterals* with

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* Since this description was written, Mr. Burnup, of Durban, who sent the specimens to Prof. Gwatkin, has assured me that the two species *flammigera* and *interlirata* are conchologically identical.

one cusp, the 4th from inside, much the largest, next inside one rather large, 11–12 in all, rapidly diminishing on both sides of the big cusps, the exterior mere points.

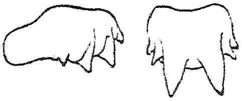
Another more mature specimen from Durban corresponds, except that both the 4th and 5th lateral cusps are very large.

Group (7) of *sphærulata*.

Rhachidian thick, deeply coloured with orange and brown, bicuspid: *laterals* degraded, cusps few and obscure.

1. *M.* "*circulata* Kien. var." Durban (Mr. H. C. Burnup*). *Rhachidian* thick, square, deep orange colour, opaque, with 2 prominent deeply-rooted cusps, the tips of which are blunt, and do not project far beyond the upper margin, these are flanked on each side by two obscure denticles or wrinkles: *laterals* thin, framework rather deep, with 4–5 deeply rooted denticles, 2–3 of which incline inward, half the margin quite bare. There are 73+ nascent rows.

Text-figure 13.



Lateral and rhachidian tooth of *Mitra sphærulata* Mart.

There is evidently some confusion in the specimens forwarded by Mr. Burnup, since those of "*circulata*" exhibit quite a different type of radula. Another specimen of "*circulata* var." in my own collection corresponds exactly with that here described.

2. *M. crenifera* Lam. Mauritius. *Rhachidian* squarish-oblong, colour deep orange-brown, almost black, 6-cusped, the 2 central strong, blunt and projecting, the side cusps smaller but distinct; base somewhat arched: *laterals* with 4–5 stumpy denticles, all inclining inward, rest of margin blank.

3. *M. sphærulata* Mart. S. Pacific. *Rhachidian* lozenge-shaped, with 2 large deeply rooted cusps mounted on a flat plate, which is superposed on the main framework, tips broad, projecting well above the upper margin; these are flanked on each side by two small obscure cusps, set in the side of the tooth and somewhat behind; sides of tooth slightly produced with small blunt wings; base slightly arched: *laterals* consisting of an obscure, rather deep-oblong plate, 3-cusped (some trace of a 4th) on inside part of the inner margin, rest blank. Rows 63+ nascent.

In a specimen from Upolu (Coll. Cambridge) and in one from Uvea (coll. A. H. C.) there are 4 lateral cusps.

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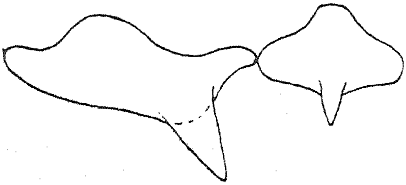
* This form, hitherto confused with *M. circula* (not *circulata*) Kien., will be described as *M. burnupiana*. Mr. Burnup agrees that it is distinct.

Group (8) of *variegata*.

Rhachidian single-cusped on a triangular plate: *laterals* degraded, with one large cusp only.

M. variegata Reeve. Mauritius. This unique and most interesting form shows a *rhachidian* formed of a simple triangular plate, with 2 angles at the extremes of the upper margin, and the 3rd in the centre of the base; in the middle of the upper margin is a single sharp, deeply rooted cusp, the tip of which projects well beyond the margin, no trace of any other cusp: *laterals* in general shape like *interlirata*, with a single strong denticle of exaggerated size, inclining inwards, no trace of any further denticles; the projecting "keel" much larger than in *interlirata*.

Text-figure 14.



Lateral and rhachidian tooth of *Mitra variegata* Reeve.

The whole radula is rather thin and lacking in substance; while the merging of all the cusps in the laterals in a single strong denticle is very suggestive of the lines on which radula development may proceed.

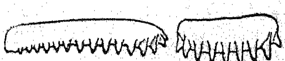
Group (9) of *ærumnosa*.

Radula small, rhachidian and laterals set with numerous small sharp cusps; framework of teeth narrow, nearly straight.

1. *M. ærumnosa* Melv. S. Africa. *Rhachidian* 8-cusped, the 6 interior equal in length, the 2 exterior much smaller; cusps sharp, small, none deeply rooted; base slightly arched: *laterals* with 12–14 cusps, the 2 or 3 interior inclining slightly, but all in the upper margin gradually diminishing in size.

2. *M. bovei* Kien. Suez. *Rhachidian* 8–9-cusped, cusps nearly equal, not deeply rooted; base very slightly arched: *laterals* with 12 nearly equal cusps, with 2 or 3 serrations at the outer end.

Text-figure 15.



Lateral and rhachidian tooth of *Mitra bovei* Kien.

3. *M. filosa* Born. Mauritius. *Rhachidian* 8–10-cusped, cusps very small, framework narrow, upper margin slightly curved; the cusps are inclined to become irregular in different teeth, and

sometimes two coalesce into one: *laterals* set with 20–24 tiny sharp denticles on a slightly curved framework, not greatly differing in size except at the extreme end, where they become very small.

4. *M. proscissa* Reeve. Karachi. *Rhachidian* 11–12-cusped, cusps tiny, sharp, close together, equal in size, upper margin slightly curved, framework very narrow: *laterals* with 13–14 cusps, the 2 or 3 innermost rather short and stumpy, the rest larger and sharp, none inclining inward; they gradually diminish to the extreme end.

5. *M. pura* A. Ad. China. *Rhachidian* 6-cusped, the 2 exterior below the plane of the rest; margin straight, base slightly rounded: *laterals* with 12–13 sharp denticles, set rather apart from one another, gradually diminishing to the end.

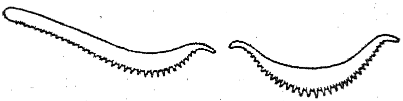
This and the following group probably represent separate branches from the parent stem.

Group (10) of *scabriuscula*.

Radula with rhachidian and laterals set with numerous small sharp cusps; framework of rhachidian narrow, deeply arched, tips curving upward; framework of laterals narrow, arched, then straight.

1. *M. circula* Kien. Durban. *Rhachidian* and *laterals* set with very numerous tiny denticles, all about the same size. The specimen is in bad condition, preventing the denticles from being counted.

Text-figure 16.



Lateral and rhachidian tooth of *Mitra scabriuscula* L.

2. *M. scabriuscula* L. Upolu. *Rhachidian* with 30–32 tiny denticles, not deeply rooted, gradually diminishing towards the ends; framework narrow at tips, deeply curved, tips bare and turning slightly upward: *laterals* with about 32 similar denticles set closely together, interior end bare of denticles, they continue to the exterior end, gradually diminishing in both directions.

The form of the rhachidian in this group, corresponding closely as it does with that of *Turricula*, forms an interesting link between the radula of that genus and that of *Mitra*, while the laterals, on the other hand, resemble in miniature those of *Mitra* proper.

Genus VEXILLUM Bolten (olim *Turricula* [Klein] auctt.).

As pointed out long ago by Gray (**3**, **4**), the *laterals* in *Vexillum*, instead of being broad and comb-shaped, with many sharp denticles, consist of a single curved blade, as in *Oliva*, *Murex*, *Trophon*, *Thais*, and the allied groups. As a rule the base is narrower, and the blade thinner than in these genera. The *rhachidian* tooth is bow-shaped, framework narrow, pointed at the ends, set either with many small sharp cusps, which cover nearly the whole of the upper margin, or with three only, closely grouped together in the centre. The whole radula is as a rule extremely small.

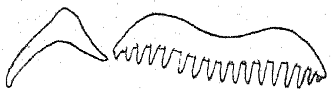
Group (1). *Rhachidian* set with many small sharp cusps, tips of framework curving slightly up, and pointed at the ends, which are bare of cusps.

1. *V. alauda* Quoy. Mauritius. Framework of *rhachidian* moderately curved, set with 16–17 minute denticles, diminishing outwardly, ends bare, scarcely turned up: *laterals* simply hooked, not deeply curved.

2. *V. arenosum* Lam. Philippines. Framework of *rhachidian* deeply arched in bow shape, set with 20–22 sharp denticles, not deeply set, which diminish gradually in size to mere points, and finally leave the ends bare, central denticle the largest; ends sharply turned up: *laterals* simple hooks, not deeply curved.

3. *V. cruentatum* Chem. Philippines. *Rhachidian* not very deeply waved; denticles 19–20, closely packed and narrow, central the largest; a small blank space at the ends of the framework: *laterals* with very narrow blades, slightly hooked at the tip.

Text-figure 17.



Lateral and rhachidian tooth of *Vexillum exasperatum* Gmel.

4. *V. exasperatum* Gmel. Mauritius. *Rhachidian* deeply curved in bow shape, ends of framework narrow and bare; set with 15–16 sharp narrow cusps, equal in size, except those at the extreme ends, which become suddenly smaller; *laterals* long and narrow, hooked at tip.

5. *V. lyratum* Lam. Mauritius. Framework of *rhachidian* deeply bow-shaped, ends scarcely turning up, tips bare; denticles 13–15, sharp, thin, rather distant from one another, central rather the largest: *laterals* long, narrow, very sharply pointed.

6. *V. nodosum* Swains. Hilo. *Rhachidian* bow-curved, but not very strongly, tips bare; denticles 7–8, sharp, triangular, close together: blade of *laterals* much curved.

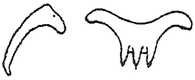
7. *V. tasmanicum* T.-Woods. N. Tasmania. Radula very small; *rhachidian* bow-shaped, well curved in centre, tips of framework bare and turned upward; denticles 10–11, sharp, close together, equal-sized, but diminishing towards the ends: *laterals* narrow-bladed, curving sharply in the centre.

8. *V. teresiæ* T.-Woods. Tasmania. Framework of *rhachidian*

not deeply bowed, tips of framework bare; denticles 10–11, central slightly the largest: blade of *laterals* narrow, somewhat angled in the middle.

Group (2). *Rhachidian* tricuspid, cusps small, placed close together in the centre of the curve, all the rest of the framework bare of cusps.

Text-figure 18.



Lateral and rhachidian tooth of *Vexillum australe* Swains.

1. *V. australe* Swains. N. Tasmania. The specimen is in bad condition, but enough can be seen to testify that the *rhachidian* is tricuspid, cusps somewhat large, central slightly the smallest: *laterals* thickish below, narrowing sharply at the ends.
2. *V. ebenus* Lam. Malta. Framework of *rhachidian* narrow, deeply arched, but scarcely waved in bow shape; cusps very close together, thin, sharp, equal in length, central slightly the narrowest: blade of *laterals* narrow, slightly hooked at tip.
3. *hizenense* Pils. Japan. Framework of *rhachidian* deeply arched in bow shape; denticles smaller and somewhat further apart than usual in this group, equal in size: blade of *laterals* long and rather narrow.
4. *V. porphyreticum* Reeve. Tonga. *Rhachidian* with framework deeply waved, cusps small, equal-sized, close together: blade of *laterals* deeply narrow, angularly curved in centre. Rows 76 + nascent.

A general survey of the Mitridan radulæ suggests several considerations.

In the first place, the rhachidian tooth exhibits wide differences of structure, ranging from the lozenge-shaped 8–9-cusped form in *Mitra*, to the unicuspid triangular form of the *variegata* group. It is probable that the investigation of further material may discover links between forms of Mitridan rhachidians at present very dissimilar. But there appears to be warrant for the suggestion that the Mitridæ represent an ancient group of Mollusca*, so that many links in the chain of development may have become extinct.

Secondly, these divergencies in the structure of the rhachidian are accompanied by a general similarity of plan in the laterals, subject however to a progressive modification in their form. We can arrange the groups and sometimes the species in a group (cf. *Imbricaria*), in a series indicating a transition from a more complex to a simpler form of tooth. The laterals, in fact, exhibit every symptom of regress towards a gradual degradation. At the head of the series we have the multicuspid lateral of *Mitra* proper, *Papalaria*, and *Dibaphus*, in which the 2nd, 3rd, and 4th cusps are slightly larger than the rest, and incline slightly inwards. The first important modification occurs in *Strigatella*, where, on the outer half of the lateral, the cusps either diminish to mere dots, or are absent altogether, leaving the framework bare. In *Imbricaria* (a parallel development) one or more of the interior cusps increases considerably in size, at the expense of the others, which generally become smaller, or are reduced in numbers and become degraded.

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* Mr. R. B. Newton informs me that Bellardi enumerates nearly 200 species of Mitridæ from the Upper Tertiaries of Italy alone, and that the genus dates back to Cretaceous rocks.

In the *flammigera* and *sphærulata* groups further modification occurs. As a rule, one of the lateral cusps is enormously developed, with a corresponding decrease in size, or with the total disappearance, of the remainder of the cusps, the whole tooth assuming a degraded appearance. In the *variegata* group the big lateral cusp has ousted all the others, and the tooth is much degraded.

According to Troschel, *Cylindromitra* (formerly *Cylindra*) *nucea* Meusch. has no laterals, while specimens of *Cy. dactylus* L. have been examined both by himself and Dr. Gray without any trace of a radula being discovered. It is possible therefore that *Cylindromitra* forms the last term in the series of degraded forms of Mitridan radula; on the other hand, it may be wiser to wait for further evidence before a final decision can be reached. Troschel's figures can seldom be accepted without confirmation. He places the *Ziervogelia* group of *Strigatella* close to *Vexillum*. If the radulæ he figures are correct, *Ziervogelia* cannot be regarded as akin to *Strigatella*; but here again further evidence is needed before the true position of *Ziervogelia* can be settled.

It is tempting to pursue this branch of the subject a little further, and to enquire whether, in the progressive degradation of the Mitridan lateral, we can obtain a clue to the genesis of the familiar bicuspid or unicuspid lateral of many of the Rhachiglossa. It seems within the bounds of possibility that the coalescing, or gradual disappearance, of the cusps, in a multicuspid lateral, produced, in more cases than that of the Mitridæ, a lateral with one or two large cusps instead of many small ones*. In *Buccinum*, *Neptunea*, *Cominella*, *Euthria*, and the allied genera, small cusps occur, with some degree of irregularity, between the two, or three, great cusps. It is conceivable that these smaller cusps may be vestiges of an armature, in which the cusps were more numerous and more on a level as regards size. Even a genus like *Alectrion*, which has settled down, in most species, to a steady bicuspid lateral, occasionally exhibits more than traces of extra intervening cusps. In most cases of bicuspid laterals, one or other of the cusps, usually but not always the interior, is decidedly the smaller of the two. This smaller cusp may show signs of incipient disappearance, a stage which receives illustration from Troschel, pl. vii. figs. 15, 19, where the inner cusp of a *Hemifusus* and a *Myristica* is very small, and pl. viii. figs. 5, 6, where the outer cusp of a *Vasum* is similarly reduced. It is no great step from laterals of this type to forms in which the second cusp has vanished altogether. The framework of the tooth would diminish in breadth, the fewer cusps it had to carry.

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* Compare B. B. Woodward, Proc. Malac. Soc. London, vii. p. 259: "In the Radula . . . there is consistent progress in the shape of the replacement of numerous, weak, little teeth by few strong ones, especially in the carnivorous groups."

This process of reduction in the rhachiglossate lateral seems to receive illustration from the case of the Volutidæ. Most species of *Voluta* have lost their laterals altogether. *Voluta concinna* and *Volutilithes abyssicola* alone retain them in a very degraded form, unicuspid on an oblong base. A further stage is shown in *Neptuneopsis gilchristi*, where the lateral cusp has vanished, and the framework is reduced to a small thin plate, of undefined shape, "probably quite functionless" (Pace **7**, Woodward, M. F. **14**).

In other genera the process of degradation takes another line. The laterals remain unimpaired, while the rhachidian suffers degradation, or even disappears altogether. *Fasciolaria*, *Latirus*, *Peristernia*, and *Fusinus* form a group of genera in which the rhachidian is reduced to extreme smallness, while the rhachidian cusps have in many species almost vanished. It cannot be doubted that the rhachidians of *Columbella* and of *Liomesus* (=*Buccinopsis*), which are now mere narrow blocks, are descendants of teeth which once were furnished with cusps.

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27. Note on the Righting Reaction in *Asterina gibbosa* Penn.

By E. S. Russell, M.A., B.Sc., F.Z.S.

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Introductory.—The experiments to be described in this paper were carried out in June 1919 on the beach of Porthmear, a little rocky bay in North Cornwall between Trevose Head and Newquay. A small colony of *Asterina* lived in the rock-pools of this bay about halfway up the beach. They did not extend further to seaward, and the reason for this appeared to be that their habitat midway up the narrow land-locked cove was less exposed to wave-action than the lower section of the beach, which at low water ran continuous with the coastal line of cliffs.

The method of experimentation was simple—the starfish were collected in twos and threes, generally from the underside of large stones, and transferred at once to shallow rock-pools, in which they could be closely observed. No specimen was used for more than ten experiments, so as to eliminate the factor of fatigue.

I attach some importance to the fact that the observations were made under natural conditions, for it is obvious that if one removes animals from their natural surroundings to the artificial conditions of a laboratory experiment their behaviour is apt to be upset by the change. Few animals seem to take kindly, for instance, to life in a smooth glass basin exposed on all sides to the light, and it is improbable that their behaviour remains unaffected by such strange surroundings. Furthermore, there is always the risk of aquarium specimens losing vigour and getting out of condition. Plessner (1913) says of *Asterias rubens* and *Solaster papposus* weakened by aquarium life that they right themselves only with difficulty or even fail to turn.

It is best, then, when studying the behaviour of any animal to study it in its native haunts or in surroundings approximating as nearly as possible to those natural to it. This was comparatively easy to manage with the Asterinas of Porthmear, and the observations recorded below, scanty though they are, have at least the merit of referring to animals acting normally in a normal environment.

The Righting Reaction.—Records were kept of the righting reaction in eleven individuals of various sizes, the exact way in which the righting movements were performed being noted, as well as the time taken, from the moment the starfish was placed on its back to the moment when it recovered its normal position and started to crawl away. The rapidity of the reaction in many cases was striking, nearly 40 per cent. of the turnings observed being completed in 20–30 seconds. These times compare favourably with the times taken by *Ophiura brevispina*, which according to Glaser (1907) averages 45 seconds for the turn. On the other hand, if things went wrong and the starfish got tied up in the peculiar way to be described later, the complete turn might take as long as 10 minutes.

The detailed records are as follows:—

Specimen A: ca. 25 mm. 13/6/19.

Time taken.	*Method of turning.*
40 secs.	Turned on two adjacent arms.
35 ,,	,, ,, ,,
24 ,,	,, ,, ,,
30 ,,	Four arms attached, two outer gave up, turned on two.
22 ,,	Three attached, one retracted tube-feet, turned on two adjacent arms.
55 ,,	Turned on two. Interfered with by a shrimp.
75 ,,	Turned mainly on one arm which bent back. Later on an adjacent arm rolled longitudinally and attached.
40 ,,	Turned on adjacent pair, but first tried to fix with arm opposite the pair on which it finally turned.

Specimen B: ca. 30 mm. 13/6/19.

20 secs.	Turned on adjacent pair.
30 ,,	Four attached, outermost gave up, turned on two.
20 ,,	Three took part, turned on adjacent pair.
30 ,,	Turned on adjacent pair.
25 ,,	,, ,,
30 ,,	,, ,,
25 ,,	Three attached, one loosed hold, turned on adjacent two.
32 ,,	Three most of the time, towards the end an outer arm gave up.
30 ,,	Turned on two adjacent.
32 ,,	,, ,,

Average time 27·4 secs.—a clever and vigorous specimen.

Specimen C: ca. 30 mm. 14/6/19.

67 secs.	First on three, then on adjacent pair.
30 ,,	Turned on adjacent two.
40 ,,	First on three, then on adjacent pair.
35 ,,	,, ,,
42 ,,	,, ,,
25 ,,	Four attached slightly, turned on adjacent pair.
25 ,,	Three ,, ,, ,,
23 ,,	Four ,, ,, ,,
32 ,,	Three ,, ,, ,,
28 ,,	Turned on adjacent pair.

Average time 34·7 secs.

Specimen D: ca. 25 mm. 14/6/19.

30 secs.	Turned on adjacent pair.
35 ,,	Three attached, turned on adjacent pair.
27 ,,	,, ,,
30 ,,	,, ,,
30 ,,	Four ,, ,,
30 ,,	Three ,, ,,
35 ,,	Turned on adjacent pair, but second choice of pair.
58 ,,	First four, then three, turned on adjacent pair.
32 ,,	Turned on adjacent pair.
25 ,,	,, ,,

Average time 33·2 secs. This specimen seemed slow at bringing over fifth arm.

Specimen E: ca. 25 mm. Rather short rays and big body. 14/6/19.

38 secs.	Turned on adjacent pair.
36 „	Three at first, one gave up early, turned on adjacent pair.
32 „	Three, then four, turned on adjacent pair.
28 „	Five attached, „ „
30 „	Three attached, „ „
32 „	Turned on adjacent pair.
33 „	Three at first, then turned on adjacent pair.
25 „	„ „ „
37 „	Principally on one of an adjacent pair.
23 „	Three for a very short time, turned on adjacent pair.

Average time 31·4 secs.

Specimen F: ca. 32 mm. 16/6/19.

115 secs.	Three attached and transitory deadlock occurred, then a fourth attached and the opposite outermost let go. Turned on three adjacent.
45 „	Three, then five, turned on two adjacent.
115 „	Turned on two, but second choice. Interfered with by surface-film which caused exploratory movements of tube-feet.

Transferred to deeper part of pool:—

45 secs.	Turned on two adjacent.
35 „	Three attached, turned on two adjacent.
43 „	Four attached, then turned on two adjacent.
60 „	Four, then three, then turned on two adjacent.
58 „	„ „ „
38 „	Two, then three, then four, turned on adjacent pair.
45 „	„ „ „ „

This specimen showed a distinct tendency to attach all arms.

Specimen G: ca. 14 mm. 16/6/19.

45 secs.	Two, then three, turned on adjacent pair.
30 „	Turned on adjacent pair.
25 „	„ „
33 „	„ „
25 „	„ „
25 „	„ „
25 „	Three, then turned on adjacent pair.
25 „	Turned on adjacent pair.
28 „	One attached, then turned on adjacent pair.
22 „	„ „ „

Average time 28·3 secs. A small and very active specimen.

Specimen H: ca. 22 mm. 16/6/19.

55 secs.	Three, then four, then turned on adjacent pair.
30 „	Four, then turned on adjacent pair.
205 „	Deadlock I. (see below, p. 429).
38 „	Two, three, turned on adjacent pair.
33 „	Two, three, four, then turned on adjacent pair.
615 „	Deadlock II. (see below, p. 429).
195 „	Deadlock III. (see below, p. 429).
42 „	Two, four, three, then turned on adjacent pair.
33 „	Three for very short time, turned on adjacent pair.
48 „	Two, three, turned on adjacent pair.

Specimen J: ca. 31 mm. 18/6/19.

72 secs.	Two, three, four, three, finally turned on adjacent pair.
60 „	Four, three, turned on adjacent pair.
52 „	Three for very short time, turned on adjacent pair.

67 secs.	One took the lead, other two attached, one of these gave up, turned on adjacent pair.
225 ,,	Deadlock IV. (see below, p. 429).
80 ,,	Two adjacent attached, tips curling in same direction, joined by a third, one of original pair gave up, turned on adjacent pair (second choice).
80 ,,	Turned on two adjacent, delayed by one opposite.
102 ,,	Turned on one, delayed by an opposite arm holding on.
120 ,,	,, delayed by an opposite pair holding on.
82 ,,	Four attached, turned on adjacent pair.

Specimen K: ca. 28 mm. 18/6/19.

55 secs.	One, three, turned on adjacent pair, hindered by opposite arm.
45 ,,	One, two, turned on adjacent pair.
25 ,,	Turned on adjacent pair.
25 ,,	One, two, turned on adjacent pair.
50 ,,	One, two, three, four, turned on second pair (adjacent).
42 ,,	Turned on adjacent pair, impeded a little by opposite pair.
52 ,,	First on one, then superseded by opposite pair, on which it turned.
90 ,,	At first one arm turned right back, then opposite pair took hold and superseded first, which retracted tube-feet.
60 ,,	One arm, superseded by opposite pair. Unifying impulse noticeable.

Specimen L: ca. 13 mm. 18/6/19.

125 secs.	One, two, turned on adjacent pair, long period of incoordination.
30 ,,	Turned on adjacent pair.
55 ,,	,, ,,
60 ,,	,, ,, impeded by opposite arm.
30 ,,	Turned on adjacent pair.
33 ,,	First one attached, then turned on adjacent pair.
52 ,,	,, ,, ,,
52 ,,	,, ,, ,,
85 ,,	Delayed reaction. Turned on two, impeded by opposite arm.
37 ,,	Turned on adjacent pair.

NOTE.—Specimen J seemed to be affected by the hot sun, so after the first four trials it was kept in the shade of a stone, as were also specimens K and L.

From these records it is apparent that while there is great variation in the way the reaction is commenced, there is great uniformity in the way in which the turning is finally accomplished—almost all turn on an adjacent pair of arms, the actual percentage in the 107 trials recorded being 92·5. In four trials the turning took place on one arm which bent back from the tip progressively: turning took place on three adjacent arms in four cases, including three of the "deadlock" turns, and in two other cases (counted as turnings on an adjacent pair) three arms were engaged until a late stage in the righting, when an outer one gave up.

When placed on its back *Asterina* immediately flattens out, then curls the tips of the arms downwards, raising itself a little. The tube-feet are extended and feel about actively. Any number of the arms may attach themselves to the bottom by their terminal tube-feet. Of these arms two or three generally get a lead over the others. The simplest case is when two adjacent arms get ahead and keep ahead of the rest. Provided the ventral surfaces of these two arms both turn inwards towards one another the righting is carried out with great precision and rapidity, often in 30 secs. or less. The two arms on which the starfish rotates are at the end of the turn disposed at a wide angle with one another, a condition recalling the usual method of righting in Ophiuroids, where the animal pushes itself over on two arms stretched out nearly in a straight line. The wide angle is immediately compensated for when the starfish begins to crawl away.

If, however, the two arms turn their ventral surfaces in one direction, so that the tips get a twist in either a clockwise or a counter-clockwise direction, the turning is delayed and other arms must be brought into play. In general, a disposition of the arms with the tips pointing in the same circular direction is a very unfavourable condition for turning, and much adjustment is required before turning can be carried out.

The turning on two arms is very often delayed by the holding on of one or two other arms, which later detach themselves. The "unified impulse" of which Jennings (1907) speaks in his elaborate analysis of the righting reaction in *Asterias forreri* is certainly shown in *Asterina*, but appears to arise rather late in the reaction. I have often seen the third arm detached rather forcibly by the pull of the turning pair. In other cases, however, one can observe a voluntary retraction of the tube-feet of the impeding arm or arms. That the unified impulse does play a great part is shown by the fact that, in general, a bad start is always or almost always compensated and a good solution arrived at, for whatever number of arms is employed at the beginning the turn is almost invariably made on two adjacent arms. If the unified impulse did not at some stage arise the righting reaction would be a long drawn-out and confused affair, coming only by chance to a successful issue.

A second neat solution of the righting problem is afforded when the righting is carried out mainly by one arm, helped towards the end of the reaction by the arms on either side. This solution is rare, and the method is not a particularly speedy one, the times taken ranging from 37 secs. to 120 secs.

A third method sometimes adopted is to turn on three adjacent arms. On condition that the middle arm of the three takes the lead this method is quite successful: it is, in fact, hardly to be distinguished from the method of turning mainly upon one arm. If, however, the middle arm lags behind and the outer arms get ahead of it, trouble ensues and a deadlock occurs

Turning on four arms is really not met with. Four arms may firmly attach and an attempt be made to turn on all four, but the actual turning must take place on the middle pair, the outer arms being forced to let go. An attempt to turn on four resolves itself into a turn on a single pair.

If all five arms attach, no progress can be made until at least two relax their hold.

Comparison with the account given by Jennings of the methods used by *Asterias forreri* shows that *Asterina* attempts practically all the methods employed by *Asterias*, but is successful only in the measure that its organisation permits. *Asterina* is a short-rayed, comparatively rigid form, and cannot twist its rays (especially round a longitudinal axis) to anything like the extent possible to the long-rayed *Asterias*. Its righting reaction is accordingly less varied than in *Asterias*, for the simple reason that certain solutions open to *Asterias* are mechanically extremely difficult or quite impossible for *Asterina*. Organisation, in fact, must be regarded not only as a means towards action, but also as a limit upon activity—a limit which the animal in its active striving tries always to overcome.

The following is a summary in Jennings' own words of the various modes of righting which he has observed in *Asterias forreri*:—

"1. The simplest and neatest method of turning is the following: Two adjacent rays twist their tips in such a way that the ventral surfaces of the two face each other; then the tube-feet of these rays attach themselves and throw the starfish over in a neat somersault......

"2. The tips of the two adjacent rays may so twist that the ventral surfaces do not face each other, but both face in the same direction. The tube-feet then take hold and throw the starfish over,—twisting it about an axis which passes lengthwise through one of the attached rays. This method of turning is extremely difficult and awkward, but is seen at times. Usually when two rays become attached in the way described, a third ray takes hold and aids the turning, the method then forming a transition to that given next......

"3. Three adjacent rays twist, attach themselves, and remain attached, all pulling throughout the reaction. Usually the animal turns primarily by the aid of the two outer rays, while the middle one is relatively passive, and is compelled to double back under as the animal turns. Often this middle ray walks backward beneath one of the other rays, or the other walks actively over its surface or there is a combination of these two movements, till the normal position is reached......

"4. Four of the rays take hold, two extending to the right, two to the left ...... [all remain attached during the turn].

"5. All of the rays attach themselves. Now the turning can be accomplished only by the release of certain rays ......

"6. An unusual method is that in which but one ray twists and attaches itself, and by its unaided efforts turns the starfish about an axis passing through this ray......

"7. A still more unusual type is seen in the performance of the righting reaction without attachment of the tube-feet of any of the rays...." (1907, pp. 125 & 128).

This last method, in which the starfish raises its disc high by standing on the tips of all five rays and then swings one or more rays over or under until it topples over right side up, I have not observed in *Asterina*, and Jennings has seen it in *Asterias* only when the tube-feet were prevented from taking hold.

Method 6 is used by *Asterina*, but the turning is round an axis transverse to the ray, not longitudinal as Jennings' account seems to imply. (In general, the inverted *Asterina* tends to roll its rays backwards from the tip rather than twist them to the side round a longitudinal axis, as is customary in *Asterias*.)

Method 1 is in *Asterina* as in *Asterias* the neatest and most successful solution. Method 2 also occurs, but seems in *Asterina* always to require the assistance of a third ray, which generally supersedes one of the original pair. Method 4, as already pointed out, is not mechanically possible in *Asterina*.

It is in Method 3 that the difference between the two species comes out most clearly. If *Asterina* tries to turn on three rays and the two outer get ahead, the middle one becomes sharply bent back upon itself and is unable to straighten out owing to the rays on either side pinning it down hard against the bottom. A deadlock follows, which lasts for several minutes, the two unattached rays standing up almost vertically in the water, the whole turning movement being suspended half-way.

One gets the impression that the starfish is thoroughly puzzled by the situation, and it certainly takes a long time to arrive at a solution. Various solutions are found. In Case I. (*supra*, p. 425) the starfish finally bent down one of the free rays and took hold, then relaxed the two outer attached rays enough to push the middle ray through. In Case II. both of the free arms were bent down and attached, then one of the original outer pair let go and so released the prisoned ray. In Case III. the free arms bent down and attached, pulling the body flat by main force, the prisoned ray being subsequently freed by adjustment of the neighbouring rays. In another case, not included in the general series, in which the deadlock lasted about 4 minutes, an outer ray let go, and the starfish turned on the other two attached rays, the free arms taking no part in the solution. Case IV. in the general series was of another character. Three rays had attached, the tips of two rays twisting towards one another; then a fourth ray took hold; finally the starfish turned on a pair of rays at the side, having taken over three and a half minutes to work out this solution.

In *Asterias*, when three rays attach and the outer rays get ahead, as is apparently usually the case, turning is carried out with comparative ease, the length and flexibility of the rays permitting the middle ray to crawl over or under the ones at the side, instead of being pinned between them as happens in *Asterina* with its short and flat rays.

I did not investigate the question as to whether the individual *Asterina* shows any preference for using a particular ray or combination of rays, as Jennings has demonstrated for *Asterias forreri* (1907, p. 144), but it is clear from the detailed records given above that each individual tends to stereotype the method used in the first few trials. Some specimens, notably B and G, turned unhesitatingly on an adjacent pair, F showed a tendency to attach all its rays, H got itself tied up in a deadlock three times in ten trials, K showed a propensity to use one ray for turning. It is difficult to say whether these tendencies are due to individual idiosyncrasy or to the formation of transitory habits.

Perceptions involved in the Righting Reaction.—When *Asterina* is turned on its back two obvious changes take place in its relation to environment—the tube-feet lose contact with the bottom, and the action of gravity upon the animal is reversed in direction. The irritating effect of light upon the ventral surface need not be considered as an essential factor, for, according to Preyer (1886–7, p. 99), the righting reaction may take place in the dark. The stimulation of the dorsal surface by contact with the bottom may also be eliminated from the essential conditions, since *Asterina* is often found under stones with its back in contact with the bottom. And Preyer (*ibid.* p. 107) has shown that removal of large pieces of the dorsal integument does not hinder the righting reaction.

In order to study the relative importance of the two main conditioning factors—contact and gravity—I carried out the following experiments on the beach with a couple of large and active specimens:—

I. The starfish was turned on its back, and a small piece of slate was held 1–2 mm. above the ventral surface. The starfish attached completely and could be lifted away adhering to the slate—the righting reaction was not carried out, the starfish remaining back downwards. If, however, the slate was not lifted away and the starfish remained in contact with the bottom, it left the slate and crawled on to the bottom, thus completing the righting reaction. (10 trials.)

II. The slate was presented half-way through the turning movement. The starfish attached some of its tube-feet temporarily but completed the turn towards the bottom. (10 trials.)

III. A piece of *Fucus* of about the same area as the starfish was placed on the ventral surface of an inverted *Asterina*. The animal attached its tube-feet and carried out "walking" movements with them, by means of which the weed was carried right off the ventral surface. The starfish then proceeded to turn.

IV. The starfish was held lightly in position by means of angled pins on the under side of a floating block of wood, the ventral surface facing earthwards. It turned so as to bring its ventral surface into contact with the wood. In spite of the fact that the pins interfered somewhat with the righting movements, less than one minute sufficed in two cases for the turn, less than two minutes in three other cases.

V. Propped up with its back against a vertical side of rock, the starfish invariably turned towards the earth, pivoting rapidly on the pair of arms whose tips were in contact with the horizontal surface.

From these experiments it seems clear that the primary aim of the righting reaction is to bring the tube-feet into contact with a solid and resistant surface. The first thing *Asterina* does when detached from its hold is to stretch out its tube-feet and feel round in all directions. Mere tactile contact is, however, not sufficient, as Experiment III. shows—the surface must resist a pull. The perception involved in the contact reaction is not so much tactile as kinæsthetic. It does not seem to matter very much whether the surface of adhesion lies below the starfish, as in the normal righting reaction, or above it, as in Experiment IV. There is no pronounced tendency to take up a definite position relative to gravity. Under natural conditions *Asterina* may be found either adhering back downwards on the underside of a stone or back upwards on the bottom underneath the stone, or again wedged along the lateral edges of the stone. Experiment I., however, indicates that *Asterina* prefers to turn its ventral surface to the bottom rather than crawl on a small inverted stone, and this fact might be adduced, together with the similar results obtained by Preyer (*ibid.* p. 116), in favour of graviperception taking a part in the reaction. On the other hand, *Asterina* may crawl off the piece of slate simply because of its small area. (The result of Experiment II. is best explained as due to that "persistence of an established impulse," which is a characteristic feature of the behaviour of many lower animals (Jennings, *ibid.* pp. 115–6, 145–6).

The probability is that graviperception in the starfish, if really existent, is purely kinæsthetic. It is well known that when a starfish is walking undisturbed over a horizontal surface the tube-feet do not attach firmly to the bottom but act very much like legs which push the animal forward. This has been clearly shown by Jennings for *Asterina forreri*, and is true also of *Asterina*. If, however, *Asterina* is irritated it huddles down and grips the bottom firmly with its suckers. Also when at rest it holds on fairly tightly. Similarly, if it is mounting a steep slope, or adhering to the under surface of a rock, it must hold on tighter, bringing its suckers into play. Graviperception in *Asterina*, if one can properly use the term, must be little more than a dim perception of the difference between a surface on which it may walk and a surface to which it must cling. This gives the possibility of a choice between a back downwards and a back upwards position. Space to the starfish must be a tactile or better a kinæsthetic space.

To sum up, the two factors provisionally distinguished above—contact and gravity—probably resolve themselves into one, for both appear to depend upon kinæsthetic impressions. The aim of the reaction is to get a firm foothold on something solid; once this is found the starfish is probably able to distinguish by muscle sense, in a rough and ready way, whether the surface is horizontal, vertical, or inverted.

It is possible that a third factor plays a part in the orientation of the body with respect to gravity—the drag or pull of the internal organs. The existence of this factor was recognized by Preyer (*ibid.* p. 121), and its importance in Crustacea has recently been emphasized by W. von Buddenbrock (1914). As the starfish shifts its position with respect to gravity the internal organs, or at least such of them as are slung by mesenteries, must shift their position within the body. It is conceivable that such alterations in stress are perceived by means of an interoceptive nervous mechanism. In Experiment V., for instance, the stimulus to turn to the horizontal may have been supplied by the downward drag of the internal organs.

In conclusion, a remark upon method may perhaps be permitted. If the whole reaction is considered as behaviour in the real sense, that is to say, considered strictly from the psychological point of view—as has in effect been done in the above discussion—the problem ought not be formulated in terms of physiological reaction to single environmental stimuli, but in terms of response to a situation presented to the animal as a whole, or, in the case of an experimental dissociation of the normal combined action of the factors involved (as in Experiment IV.), in terms of response to one factor as representative or suggestive of the whole normal presented situation.

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28. Experiments on Sex Determination.

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The experimental work forming the basis of the present communication was carried out at intervals, as opportunity served, during the years 1902–1905. But although the main outcome of the work was demonstrated (with the aid of lantern-slides) to the Physiological Society in May 1908, and at the Dublin meeting of the British Association in September 1908, no account of it has previously been published. The reason for this omission is to be explained by the unfortunate fact that the collection of diagrams and other records, which was handed over by the writer, for purposes of criticism, shortly after the research came to an end, has only recently been recovered.

From the earliest ages various writers have suggested the possibility that the reproductive glands, male or female, or both, were concerned in the production of offspring of one or the other sex. The most prevalent idea would seem to have been that the glands of one side of the body gave rise to male-producing spermatozoa or ova respectively, and *vice versâ*. Some observers, among the most recent of whom Dr. Rumley Dawson should be mentioned, have favoured the supposition that the male or the female gland only was concerned; while others have elaborated the necessity for inter-action of spermatozoa and ova produced by the reproductive glands of the same, or of opposite sides of the body.

In the hope of definitely determining whether or not any of these suggestions could be shown to possess basis of scientific fact, a series of experiments were devised which were carried out on a somewhat extensive scale. The animals employed for the purpose of these experiments were, for the most part, rabbits, although use was also made, to a smaller extent, of pigs, cats, guinea-pigs, and mice. Of these animals the greater number were semi-castrated, or semi-spayed (according to sex), and subsequently kept under observation until such time as they had completely recovered from the operation. An additional number of animals which had already been operated on in this fashion were obtained from dealers and breeders. In a later series of experiments, with the object of avoiding possible fallacy from the loss of an internal secretion, ligature in two places of the uterine cornu, or of the cord (subsequently of the vas deferens only), on one side of the body, with partial or complete section of the tissues between the ligatures in order to prevent possible regeneration, was substituted for ablation of the ovary or testicle respectively.

Ultimately the experimental animals were bred:—

(*a*) with entire animals of the opposite sex,

(*b*) with other semi-castrated, or semi-spayed individuals, in such manner as was intended to comprise all possible permutations. Owing, however, to loss of animals from inter-current disease, more particulary tuberculosis, and from accidents of one and another kind, it did not prove possible to carry out the scheme in its entirety.

The intended scheme of the breeding experiments may perhaps be best shown in tabular form as follows:—

♂ Entire.	Bred with	♀ R.
♂ Entire.	,, ,,	♀ L.
♂ R.	,, ,,	♀ Entire.
♂ R.	,, ,,	♀ R.
♂ R.	,, ,,	♀ L.
♂ L.	,, ,,	♀ Entire.
♂ L.	,, ,,	♀ R.
♂ L.	,, ,,	♀ L.

(R. = possessing gland on Right side only.
L. = ,, ,, ,, Left ,, ,,)

Without entering into details concerning the number and sex of the offspring resulting from interbreeding on this plan, it may be mentioned that although, so far as possible, each particular mating was repeated on one or more occasions, in only four instances were families of one sex, either all males or all females, obtained. But even so, when the same animals, or animals in similar condition, were again mated, a uni-sexual family was not again obtained, definite indication being thus afforded that the result obtained in the first instance was quite fortuitous. As an instance of *completely contrary* results, in respect of offspring, obtained on mating two sets of animals in similiar condition the following experiments may be cited:—

March 17th, 1902.

Bernau buck: *Castrated on* Left *side* + Bernau normal *doe.*
Litter = 5 M, 0 F.

June 5th, 1902.

Blue buck: *Castrated on* Left *side* + Wakehurst normal *doe.*
Litter = 0 M, 2 F.

while the mating of yet another similar couple was as follows:—

September 12th, 1902. Litter = 2 M, 1 F.

Equally divergent results were obtained as the result of crossing semi-spayed does with normal bucks; or when bucks and does, in both of which the reproductive gland of one or the other side had been removed, or put out of action as the result of a vasectomy, or section of a tube, were mated.

In the later series of experiments the female was killed shortly before her litter was expected, in order that the young might be examined *in situ* in the uterine tube or tubes, as it seemed not improbable that useful information might be obtained from determining the relative position in the tube of fœtuses of one or the other sex. Records of the results obtained were indicated in the form of a simple diagram, devised for the purpose. (Lantern-slides of these were shown on the screen.) One point of interest emerging from study of these diagrams is the frequent occurrence of male couples. Whether these, as in the case of identical twins in the human subject, are to be regarded as the outcome of division of a single ovum could not be certainly determined.

In a lecture on "Internal Secretion and the Ductless Glands" by Dr. Swale Vincent (Lancet, Aug. 1, 1906, footnote) will be found a reference to a further outcome of this investigation, personally communicated to him, "pointing distinctly to an internal secretion on the part of the interstitial cells" of the testicle. Dr. Vincent notes that the "results are generally in agreement with those of Ancel & Bouin (Recueil de Médicine Vétérinaire, Jan. 15, 1904)." It became apparent also that in the case of those rabbits in which the vas only was tied (with careful exclusion of blood-vessels and nerves), the animals, as contrasted with those in which semi-castration had been performed, showed no diminution of desire, or capacity, for sexual intercourse; while, on the average, they obtained larger families.

The communication also included an experimental and critical review (illustrated by lantern-slides) of previous work on sex determination by various observers whose investigations had dealt with the study of this problem in plants, insects, and certain of the lower vertebrates.

29. The Variations in the Digastric Muscle of the Rhesus Macaque and the Common Macaque. By Chas. F. Sonntag, M.D., Ch.B., F.Z.S., Anatomist to the Society.

[Received October 24, 1919: Read November 18, 1919.]

(Text-figures 1–5.)

In the course of several dissections to explore the extrinsic muscles of the tongue of the Rhesus Macaque, I have been struck with the various appearances of the digastric muscle. I decided, therefore, to examine the muscle of every monkey brought to the Prosectorium, and the present communication is based on the dissections of fifteen animals.

The muscle belongs to Parson's first type*. In it the posterior bellies of the two digastric muscles terminate in long slender tendons which, passing forwards and inwards, unite to form an arch anterior and superficial to the hyoid bone. From the arch the fibres of the united anterior bellies pass to the lower edge of the inferior maxilla (text-fig. 1). This arch is closely applied to the mylo-hyoid muscle and compels it to have a dome-like appearance. In some cases a probe can be passed under the arch, but in most of them they are fused and can only be torn apart. Moreover, in about fifty per cent. of cases there is no connection between the arch and the hyoid bone.

The extent and nature of the attachment of the anterior bellies to the inferior maxilla vary. In some cases the muscle extends right back to the angles on both sides, but more commonly the extreme posterior limit is about half an inch anterior to the angle, and lymphatic or submaxillary glands are lodged in the small recess. In the majority of cases the attachment to the maxilla is muscular, but in one case there were a number of tendinous fibres interspersed among the muscles. In no case did I find any exception to the rule that the two anterior bellies are joined in the middle line.

In a little more than fifty per cent. of cases, the space between the tendinous arch and the hyoid bone is occupied by a membrane, by fibrous bands, or by both together. In one case, a membrane alone filled the space (text-fig. 2), and there was no fusion between it and the mylo-hyoid muscle underneath. The anterior bellies did not reach the posterior angles of the jaw.

In one case (text-fig. 3*a*) the space was filled up by a membrane, and the tendons of the posterior bellies were connected to it by short fibrous bands. This specimen was interesting in another way, for the membrane between the arch and the hyoid bone was common to the digastric and mylo-hyoid muscles, so that the two could not be separated. The mylo-hyoid muscle was defective in front, there being a V-shaped gap which was filled by membrane (text-fig. 3*b*).

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* F. G. Parsons, Journ. Anat. Physiol. 1898, p. 436.

Text-figures 1–5.

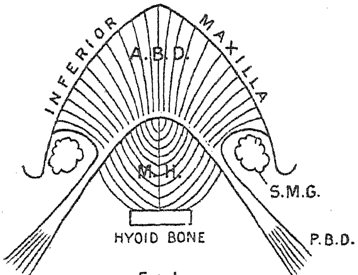


Fig. 1.

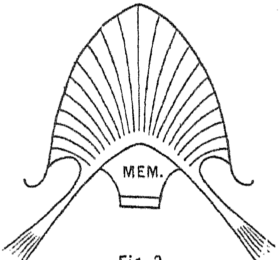


Fig. 2.

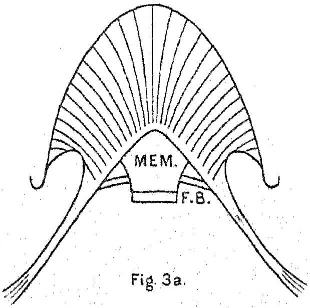


Fig. 3a.

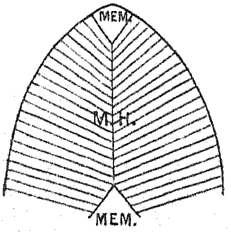


Fig. 3b.

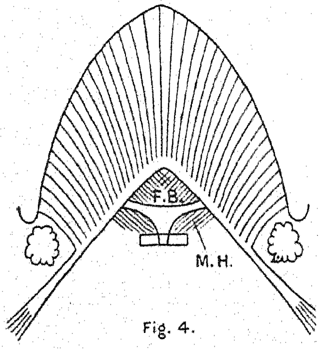


Fig. 4.

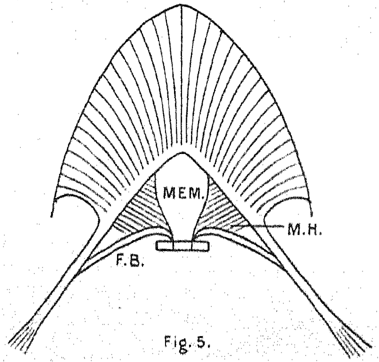


Fig. 5.

Text-figs. 1–4.—Variations in the digastric muscle of the Rhesus Macaque (*Macacus rhesus*).

Text-fig. 5.—The digastric muscle of the Common Macaque (*Macacus fascicularis*).

A.B.D.: Anterior belly of the digastric muscle. P.B.D.: Posterior bellies of the digastric. M.H.: Mylo-hyoid muscle. MEM.: Membrane. F.B.: Fibrous bands. S.M.G.: Submaxillary gland.

In six cases the space between the arch and the hyoid bone was occupied by a triradiate fibrous band, the vertical limb of the Y being attached to the bone, and the two lateral limbs to the posterior edge of the arch anterior to the posterior extreme of the anterior bellies. In the fresh specimen the contrast between the white band and the subjacent red mylo-hyoid muscle was very marked (text-fig. 4).

In the single example of the Common Macaque (*Macacus fascicularis*) which I examined (text-fig. 5), the arch was connected to the hyoid bone by a broad band of connective tissue into which two slender bands, from the tendons of the posteriar bellies, were attached.

The condition present in the Common Macaque (text-fig. 5) differs only in degree from the variety of the Rhesus Macaque present in text-fig. 3 *a*.

As there is no gap between the two anterior bellies of the digastric, and no solution in the continuity of the tendinous arch, it is not easy, at first sight, to give a rational explanation of the above appearances. I was enabled, fortunately, to examine a series of monkeys which exhibited transitions between Parson's first and third types of muscle. Each of these had one or more of the structural elements shown in text-figs. 2–5.

The variable degree of adhesion between the digastric anterior bellies and the subjacent mylo-hyoid muscle indicates the origin of the former from the latter, and is the beginning of the metamorphosis. This is followed by the appearances in text-figs. 2–5, and the condensation of the lateral fibres of the anterior bellies, constituting the nearest approach to a true digastric muscle, is the last stage.

In my opinion:—

(1) The anterior belly arises from the mylo-hyoid muscle by splitting. There then ensues:—

(2) Two muscles joined to the hyoid bone by membrane (text-figs. 2 and 3 *b*).

(3) The pull of the anterior and posterior bellies separates the latter into bands.

(4) These bands disappear leaving a muscle of Parson's first type.

(5) The tendinous arch splits and the anterior bellies separate leaving a true digastric muscle. These I have not seen in Macaques, but they are present in *Cercopithecus æthiops*, *Cercocebus æthiopicus*, and *Cebus albifrons*.

(6) The muscle in the Macaques has stopped short of being a true digastric condition in which there are two muscles, each with an anterior and posterior belly (Parson's third type).

(7) There is no variation in the posterior bellies.

30. On the Nematode Parasites of a Chapman's Zebra.

By M. TURNER, B.Sc.

[Received October 8, 1919 : Read November 18, 1919.]

(Text-figures 1–6.)

In September of this year a Chapman's Zebra, which came from Africa to the Zoological Gardens, London, ten years ago, died. The post-mortem showed that its large intestine contained many Nematode parasites. A collection of them was made by Professor Leiper, and, through his kindness, I was enabled to examine the material in detail.

Altogether seven species of Nematodes were represented in the Zebra. An enumeration of them is as follows:—

Oxyuris curvula Rud. 1803.
Strongylus vulgaris (Looss, 1901).
Strongylus edentatus (Looss, 1901).
Triodontophorus intermedius Sweet, 1909.
Œsophagodontus robustus Giles, 1892.
(?) *Cylichnostomum goldi* Boulenger, 1916.
Cylichnostomum zebræ, sp. n.

The real object of these investigations was to ascertain whether any of the parasites had lived in the Zebra in Africa, and had persisted throughout the ten years in England, or whether they had only been acquired by the Zebra since its arrival in England. This point, however, was not definitely cleared up, as none of the Nematodes found can be said to have a solely English or African distribution. Thus *Oxyuris curvula*, *Strongylus vulgaris*, and *Strongylus edentatus* are found all over the world. *Triodontophorus intermedius* has been recorded from Australia and England, and *Œsophagodontus robustus* from India and England. The localities are so far apart that it would seem probable that these species are present in intervening countries. *Cylichnostomum goldi* has been recorded only once, and that so lately as 1916, when it was found in England. More records of its occurrence and their locality are necessary before it is possible to state its distribution definitely. *Cylichnostomum zebræ* is an hitherto undescribed species.

The impression obtained from the above facts is that the Zebra acquired the majority, at least, of its parasites in England, though no definite proof of this is given.

OXYURIS CURVULA Rudolphi, 1803.

Two males were found in the Zebra. This discovery is interesting, as the males of this species of *Oxyuris* are rather rare. It was on account of this rarity that the male was only described and figured for the first time by Railliet, in 1895, although the female, under the name *Trichocephalus equi*, had been described by Schrank so long before as 1788.

Oxyuris curvula has been recorded in the Horse, Ass, and Mule.

STRONGYLUS VULGARIS (Looss, 1901).
STRONGYLUS EDENTATUS (Looss, 1901).

In 1901 Looss recognised the three species of *Strongylus*, *i. e.*, *Strongylus vulgaris*, *Strongylus edentatus*, *Strongylus equinus*, which are known to occur in the Horse, Ass, and Mule. Of them the first two were represented in the Zebra.

TRIODONTOPHORUS INTERMEDIUS Sweet, 1909.

This species of *Triodontophorus* was first described in 1909 by Sweet, whose material consisted of three female specimens obtained from a Horse in Victoria. In 1916 Boulenger found *Triodontophorus intermedius* abundantly represented in Horses in Worcestershire, England.

The female of *Triodontophorus intermedius* from the Zebra measures 18·5–21·5 mm. in length, and the male 15–16 mm. These measurements are slightly larger than those given by Sweet or Boulenger. The spicule of the male is long and rather thick. It measures 3·8 mm. in length by about 0·03 mm. in breadth at its proximal end.

ŒSOPHAGODONTUS ROBUSTUS Giles, 1892.

Œsophagodontus robustus was first discovered in Horses and Mules in India by Giles in 1892. Apparently this Nematode is rare in England, as there is only one previous record of its occurrence here. This was in 1916, when Boulenger obtained about twelve specimens from the colon of a Mare. Its numbers in the Zebra were sparse.

In the female *Œsophagodontus robustus* from the Zebra the vulva is 2·8 mm. in front of the anus. This measurement differs from that of Giles, who gives "about 1 mm.," but confirms those of Boulenger, who gives 2·3–3 mm.

The anus is 0·7–0·75 mm. from the posterior end of the body in the *Œsophagodontus robustus* from the Zebra.

(?) CYLICHNOSTOMUM GOLDI Boulenger, 1916.

The only previous record of this species was made in 1916 by Boulenger, who obtained it from the intestine and cæcum of several Horses in Worcestershire, England.

The material obtained from the Zebra and diagnosed as (?) *Cylichnostomum goldi*, consists of a single female specimen. So far as could be ascertained from this female it appears to belong to the species *goldi*, although it is somewhat longer, being 8·35 mm., than the females recorded by Boulenger. In the absence of more material it is impossible to be certain of the species at present. The diagnosis of this female was rendered more difficult by the similarity presented by the two species *Cylichnostomum goldi* and *Cylichnostomum pseudo-catinatum* Yorke & Macfie, 1919, seen in the following comparison.

Both *C. goldi* and *C. pseudo-catinatum* are described as having a small and delicate body. Boulenger gives the length of the male *C. goldi* as from 5·2–6 mm. and its maximum breadth 230μ–280μ (average 255μ). Yorke and Macfie found that the length in ten males of *C. pseudo-catinatum* ranged from 5·2–6·6 mm., and that the maximum breadth averaged 260μ. The females of *C. goldi* were 6–6·7 mm. in length and 280μ–300μ (average 290μ) in breadth. Ten females of *C. pseudo-catinatum* measured from 6·1–7·7 mm. in length and averaged 320μ in breadth. These measurements show that the size of the body of the worms of both species is practically identical. The slight difference between the two species present here is not greater than that between the measurements of individuals of the same species.

A neck is reported to be absent in *C. goldi*, but present in *C. pseudo-catinatum*. In the figure of the former species, however, a very slight constriction in the neck region is seen.

The mouth collar in both species is marked off from the rest of the skin by a definite constriction. In the figures given, the mouth collar, in both, is seen to be of a similar shape, being rather high and almost ellipsoidal in lateral view.

The submedian head papillæ in *C. goldi* are small and do not project beyond the middle of the external leaf crown. In *C. pseudo-catinatum* these papillæ are larger and project beyond the anterior edge of the external leaf crown. In both species the submedian head papillæ are conical and their extremities are not separated off by lateral notches.

Boulenger says that the lateral head papillæ of *C. goldi* are very inconspicuous, while Yorke and Macfie say that those of *C. pseudo-catinatum* are prominent. In the figures, however, the lateral head papillæ of both species appear very similar as regards size, in relative proportion to the rest of the head, and in shape.

Boulenger gives "about 20" as the number of elements in the external leaf crown of *C. goldi*, while Yorke and Macfie give 20 as the number of these in *C. pseudo-catinatum*. These leaves are large and pointed in both species.

The number of leaves in the internal leaf crown of *C. goldi* is given as 30–32, and Boulenger says that these leaves are shorter than those from the external corona. Yorke and Macfie only say that the internal leaf crown of *C. pseudo-catinatum* consists of numerous long narrow elements. Their figure shows these to be shorter than the leaves of the external corona. In both *C. goldi* and *C. pseudo-catinatum* the internal leaf crown arises in more than one plane. This arrangement is present in the other members of this group of Cylichnostomes, *i.e.*, *C. catinatum* and *C. alveatum*.

The mouth capsules of both *C. goldi* and *C. pseudo-catinatum* are like those of *C. catinatum* and *C. alveatum* in being ellipsoidal in transverse section, with the longer axis dorso-ventral. The mouth capsule of *C. pseudo-catinatum* is described as having an oblique floor. This character is not mentioned in *C. goldi*. The optical section of the mouth capsule differs in the two species. In *C. goldi* the walls in ventral view converge anteriorly, while in *C. pseudo-catinatum* they converge posteriorly. The height of the mouth capsule of *C. goldi* is given as "about 20μ." In the males of *C. pseudo-catinatum* this height varies from 22 5μ–25μ and in the females from 24μ–29μ, so that from these measurements the mouth capsule of *C. pseudo-catinatum* appears to be slightly larger than that of *C. goldi*. The measurement of the breadth of the mouth capsule has been undertaken in such different ways in the two species that it is not possible to compare the measurements given. From the figures it appears that the proportion of the breadth of the mouth capsule to its height is greater in *C. pseudo-catinatum* than in *C. goldi*.

The dorsal œsophageal gutter does not project into the mouth capsule in either species.

The œsophageal funnel is well developed in both *C. goldi* and *C. pseudo-catinatum*. In the latter, however, cuticular thickenings lining this funnel are not figured.

The œsophagus in eight males of *C. pseudo-catinatum* varies in length from 314μ–349μ and in breadth from 70μ–82μ. In eight females the œsophagus varies in length from 322μ–363μ and in breadth from 72μ–83μ. Taking the outside of these measurements the œsophagus of *C. pseudo-catinatum* varies from 314μ–363μ in length and from 70μ–83μ in breadth, and these measurements are not very different from the 300μ–350μ in length and the 70μ–75μ in breadth that Boulenger gives for the œsophagus of *C. goldi*. In the œsophagus of both species the posterior bulb is not markedly swollen.

The cervical papillæ of *C. goldi* are situated about 270μ–300μ from the anterior end of the body. In *C. pseudo-catinatum* the cervical papillæ are at about the same level as the excretory vesicle, that is from 67μ–152μ from the posterior end of the œsophagus. It is not possible to compare these two sets of measurements. In the figure of *C. goldi* that part of the œsophagus behind the excretory vesicle is about one-fourth of the length of the whole œsophagus, while in the figure of *C. pseudo-catinatum* the proportion of the same two parts is one-third. It may be that this figure of *C. pseudo-catinatum* is that of a specimen where the excretory vesicle is about 152μ from the posterior end of the œsophagus. In the figures the cervical papillæ of *C. goldi* are slightly more posterior in relation to the excretory vesicle than those of *C. pseudo-catinatum*.

Female. In both *C. goldi* and *C. pseudo-catinatum* the posterior region of the female is bent dorsally to make almost a right angle with the axis of the rest of the body. In both, the tail behind the anus is narrowed suddenly to form a point. The figures show that the relative proportion of the ovi-projector to the vagina is about the same in both species. The ventral prominence and other curves in this region of *C. goldi* appear less than those of *C. pseudo-catinatum*.

Boulenger gives the distance between the anus and vulva of *C. goldi* as about 90μ–100μ, and for the same in *C. pseudo-catinatum* Yorke and Macfie give 45μ–85μ. Thus the anus and vulva are almost the same distance apart in, at least, some members of the two species.

Male. The two descriptions of the posterior regions of the males of *C. goldi* and *C. pseudo-catinatum* are identical in many important points.

The median dorsal lobe of the bursa is short and almost semicircular in both species. In both, the dermal collar is well developed on the anterior and posterior (ventral and dorsal, Yorke & Macfie) surfaces. The pre-bursal papillæ are well developed in both.

The genital cone of both species is similar in having its appendages in the form of very thin delicate plates (slight elevations, Yorke & Macfie) each provided with two slender finger-shaped processes. Of these two processes the inner one is the larger in both species. The figure of the genital cone of *C. goldi* is indeed very similar to that of *C. pseudo-catinatum*.

In *C. pseudo-catinatum* the main trunk of the posterior ray of the bursa and its second lateral branch are each provided with a small accessory branch. Boulenger makes no mention of any accessory branches in his description of *C. goldi*, but his figure of a lateral view of the bursa shows an indication of one on the second lateral branch of the posterior ray, though nothing is seen on the main posterior ray. In the lateral view of the bursa of *C. pseudo-catinatum* the accessory branch of the main posterior ray is not shown.

Boulenger makes no mention of the spicules of *C. goldi*, so it it is not known whether they resemble or differ from those of *C. pseudo-catinatum* which are figured by Yorke and Macfie.

This comparison of the two species, made only from descriptions and figures, was made more difficult by the different methods of treatment employed by the different writers. Nevertheless enough has been shown to prove that there are some features of very great similarity, if not of identity, in *C. goldi* and *C. pseudo-catinatum*.

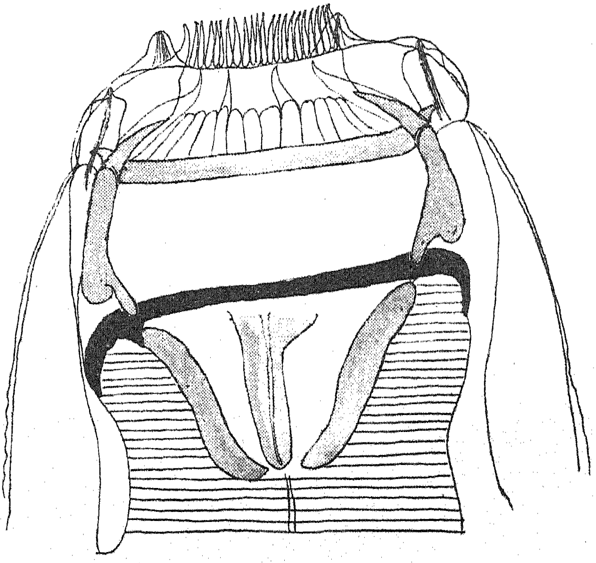
CYLICHNOSTOMUM ZEBRÆ, sp. n.

Specific diagnosis :—

Cylichnostomum zebræ is one of the largest of the Cylichnostomes, being slightly larger than *C. elongatum*, but smaller than *C. auriculatum*, which is the largest of all members of the family. The male of *C. zebræ* measures 13–13·5 mm. in length and has a maximum thickness of 0·75 mm. The female is 17–20·5 mm. in length with a maximum thickness of 1 mm. Two males and ten females were measured. The body is thickest in the middle, but is quite thick throughout most of its length. About 3 mm. from each end it tapers to the extremities.

The wall of the intestine, especially the anterior end, is dark with a brownish pigment.

Text-figure 1.



Cylichnostomum zebræ, sp. n.

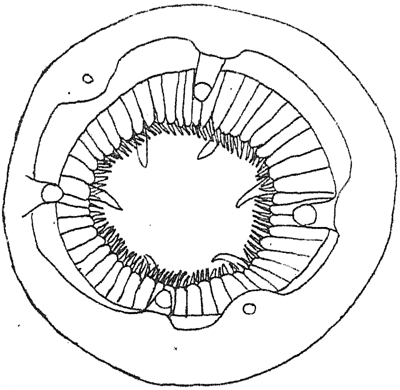
Anterior end of body. View from dorsal side.

The cuticle is finely striated, the striations on the middle of the body being 15μ apart.

The head is marked off from the body by a very slight constriction. It has a diameter of 280μ–300μ in the five specimens measured. The mouth collar is well developed, with a height of $\frac{1}{3}$ the breadth. It is almost ellipsoidal in shape, being flattened anteriorly. The lateral head papillæ are broad and do not project beyond the mouth collar. The submedian head papillæ are rather large and conical and project almost to the anterior edge of the external leaf crown.

The external leaf crown consists of 85–93 narrow and pointed leaves, which project well in front of the anterior margin of the mouth collar. The internal leaf crown has 48–59 leaves. Each leaf is rather blunt and is about twice as broad as one from the external leaf crown. Amongst the ordinary cuticular leaves of this internal corona are six longer sharply-pointed ones. They are also more refractive.

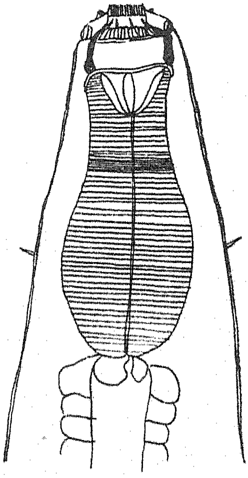
Text-figure 2.



Cylichnostomum zebræ, sp. n.

Anterior end of body. View from above.

Text-figure 3.



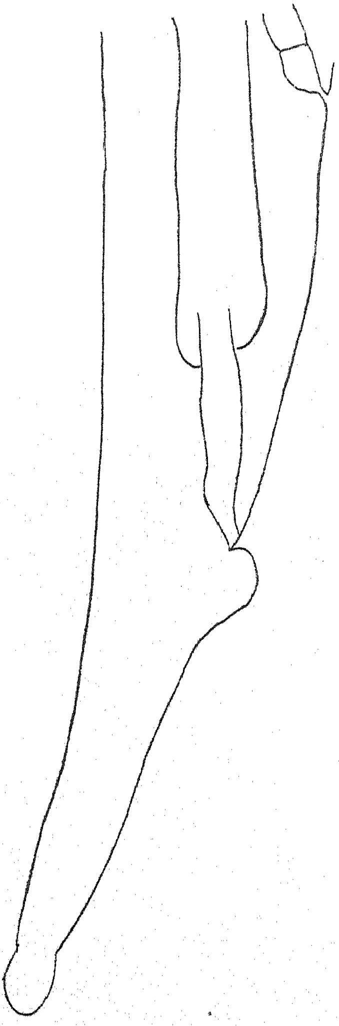
Cylichnostomum zebræ, sp. n.

Anterior end of body. View from dorsal side.

The condition of the leaf crowns in *C. zebræ* recalls that in *C. bicoronatum* and *C. euproctus*, for in these three the internal leaf crown consists of fewer leaves than the external crown. In other Cylichnostomes the reverse of this is the case.

The mouth capsule has a height (from the anterior end of the œsophagus to the base of the leaves of the internal corona) of 85μ–90μ and a breadth of 210μ–250μ. In optical section its

Text-figure 4.



Cylichnostomum zebræ, sp. n.

Posterior end of Female. Lateral view.

walls seem to be composed of two parts jointed together. The anterior part is pointed and curved inwards, bearing on its posterior outer side a short spur. The posterior part of the mouth capsule wall is thick and becomes broader towards the base, which is notched to form two parts, one narrow and the other broad and rounded.

There is no dorsal gutter.

The œsophagus is 675μ–800μ in length and 300μ–350μ wide at its broadest part. It is flask-shaped, with the nerve ring at the base of the neck portion. The œsophageal funnel is well developed. The anterior end of the œsophagus is covered with a cap of cuticle, which forms the floor of the mouth capsules and is oblique from side to side.

The cervical papillæ are 660μ–700μ from the anterior end of the body and are situated halfway between the nerve ring and the posterior end of the œsophagus.

The excretory pore is slightly in front of the cervical papillæ.

Female. The posterior region is usually in a straight line with the rest of the body, but may be bent slightly dorsally. It tapers to the tip, which is rounded and rather knob-like.

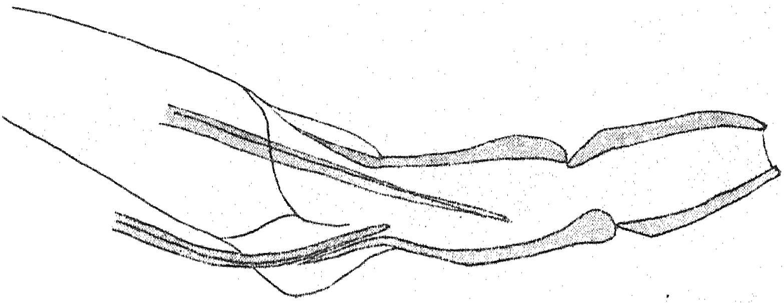
The vulva is 1·6–2 mm. from the posterior extremity and 0·9–1 mm. in front of the anus.

The vagina is about 0·6 mm. in length.

The eggs are 70μ–80μ long by 50μ–55μ broad.

Male. The genital cone is small. More detailed examination of it was not possible, as it was somewhat damaged in both males.

Text-figure 5.



Cylichnostomum zebræ, sp. n.

Accessory piece of Male.

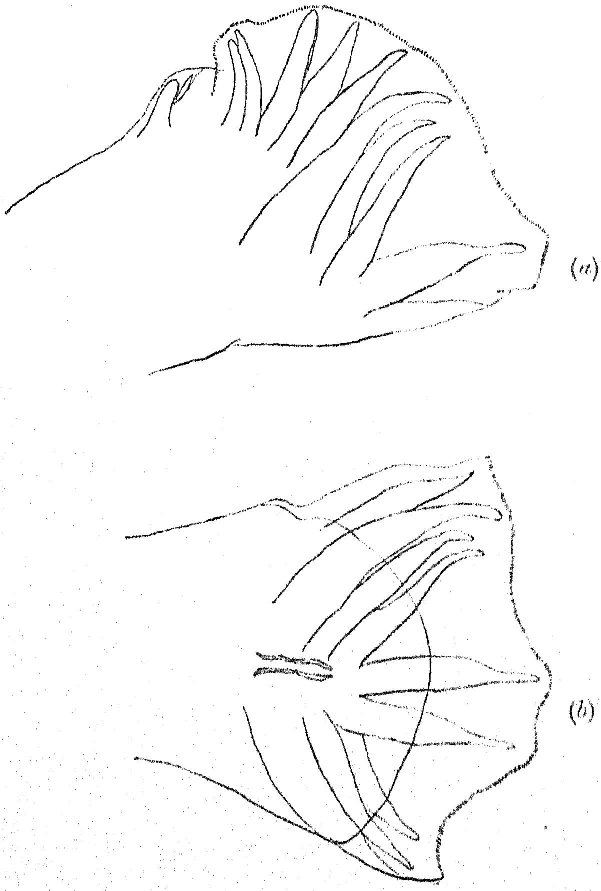
An accessory piece is present. It is saddle-shaped with inturned lateral margins. Its proximal end is bifid, each part ending in a point. The spicules are thick and about 0·95 mm. in length. Their distal ends seem to be simple points.

One of the most striking characters of the male is the finely serrate edge of the free margin of the bursa. This is a character only described in *C. poculatum* amongst the Cylichnostomes.

The pre-bursal ray is short and the dermal collar small.

The median lobe of the bursa is very short and notched. The dorsal ray, which narrows abruptly to form a finger-like distal extremity, with its two branches arising together and equal in length, differs from the dorsal ray of the bursa of any Cylichnostome hitherto described. So that the dorsal ray forms one of the chief distinguishing features of *Cylichnostomum zebræ.*

Text-figure 6.



Cylichnostomum zebræ, sp. n.

Bursa of Male. (*a*) Lateral view. (*b*) Dorsal view.

Another character peculiar to *C. zebræ* is the possession of the six elongated and highly refractive leaves interspersed between the ordinary leaves of the internal leaf crown. These specialised leaves have not been recorded in a Cylichnostome before.

In passing the final proofs of the above paper for press on January 27th, 1920, I note that the Nematode described therein as *Cylichnostomum zebræ* n. sp. has been named *Hexodontostomum markusi* n. gen. n. sp. by Ihle in Cent. f. Bakt., Abt. i., Orig. Bd. 84, 1920, Heft 1.

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Yorke, W., & Macfie, J. W. S. (1919). "Strongylidæ in Horses. vi. *Cylicostomum pseudo-catinatum*, sp. n." Annals of Trop. Med. and Parasitology, vol. xii. Nos. 3 & 4, February, 1919.

* Not seen.

31. The Development of the Mesenteries in the Actinian *Urticina crassicornis**. By James F. Gemmill, M.A., M.D., D.Sc.

[Received August 18, 1919 : Read November 18, 1919.]

(Text-figures 1–5.)

The adult *Urticina* is remarkable for having its mesenteries and tentacles apparently arranged in 10-cycled symmetry (Dixon **4**, Faurot **5**, Haddon **7**), and on that account has been placed by various authors among the Paractineæ. It is, however, a Hexactinian, the arrangement of whose mesenteries has become modified during early growth.

The species investigated was the large fleshy one with few warts, occurring beyond tide-mark down to a depth of at least 35 fathoms, variously and often brightly coloured, attaining a size, when fully grown, of over six inches in expanded disc diameter, and having 160 tentacles of which 80 occur in the outermost circle. The other circles from within outwards consist respectively of 10, 10, 20, and 40 tentacles. Gosse (**6**. p. 211) thinks that this is just the shore species (his *Tealia crassicornis*) modified for living under water, though he also describes an apparently identical form as a separate species under the name *Bolocera eques* (**6**. p. 351). I find that in the Firth of Clyde both the shore and the submerged forms shed their eggs prior to fertilization (a distinction from *Rhodactinia crassicornis* (**3**. pp. 39, 41)), that development is the same in both, and that cross fertilization can occur between them. On general grounds I would have judged that the shore and the submerged forms were varieties of the same species had my account (see below) of the development of the mesenteries in the latter agreed with that of Faurot (**5**. p. 172) for the former. It appears to have been the submerged species whose development was investigated by Appellöf (**1**). T. A. Stephenson, reviewing the nomenclature in a note to me, concludes that the shore form should be called *Urticina* (Ehrenberg) *coriacea* (Cuvier), and the submerged form *Urticina* (Ehrenberg) *crassicornis* (O. F. Müller), and that the two are probably distinct species.

My material consisted of (*a*) young specimens reared to the 12 mesenteried stage from eggs shed in the tanks at the Millport Biological Station, and (*b*) growth stages dredged from c. 20 fms. near the Station, the youngest of which had only 12 tentacles. All were studied by the method of serial sections. Of the 8 *Edwardsia* mesenteries, the ventro-laterals are the earliest to develop and the laterals the next, while the ventrals (sulcars) and dorsals (sulculars) appear almost simultaneously a short time afterwards. Throughout the text-figs. these mesenteries are numbered 1, 2, 3, 4 respectively. Attachment of the larva then occurs, and in a week or a fortnight a new mesentery (No. 5) forms in each lateral *Edwardsia* space, and shortly thereafter a new mesentery (No. 6) in each ventro-lateral *Edwardsia* space. The

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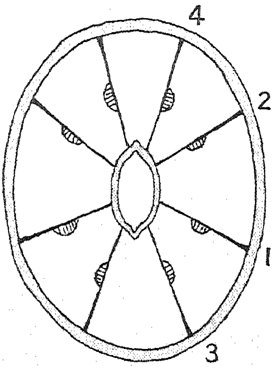
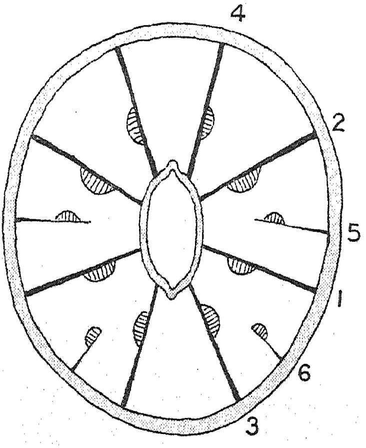
* I have to express indebtedness to the Carnegie Trust for a grant towards expenses of research work, part results of which are given in this and the following paper.

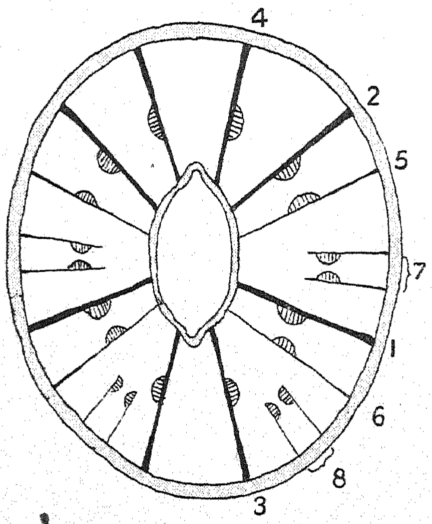
Text-figure 1.



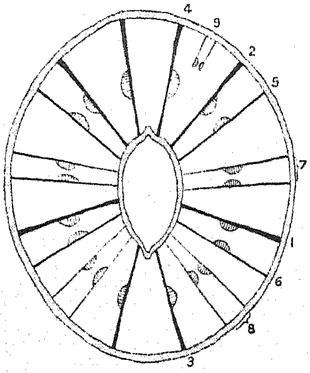
Text-figure 2.



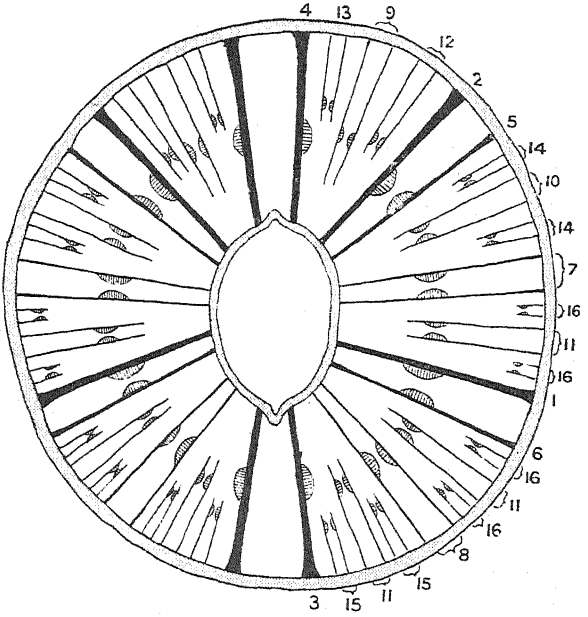
Text-figure 3.



Text-figure 4.



Text-figure 5.



Explanation of Text-figures 1–5.

Fig. 1. Transverse section (diagrammatic) of late larva of *Urticina crassicornis* to illustrate the arrangement of the 8 *Edwardsia* mesenteries.

Fig. 2. Similar transverse section, fourteen days after fixation, to illustrate the early 12 mesenteried stage.

Fig. 3. Diagrammatic transverse section of early growth stage in which an additional pair of mesenteries (Nos. 7, 8) has appeared in each lateral and ventral primary exocœle.

Fig. 4. Similar section of later growth stage in which the additional mesenteries seen in fig. 3 have become mesenteries of the Ist Order, and a further pair (No. 9) belonging to the same (*i. e.*, the 2nd) cycle has appeared in each dorsal primary exocœle. The latter will ultimately take rank as a mesenteric pair of the IInd Order.

Fig. 5. Similar section of still later stage in which (*a*) mesenteric pairs 10, 11 (3rd cycle mesenteries) have appeared and are growing forward to take rank with 9 as mesenteries of the IInd Order, while (*b*) new mesenteric pairs of the IIIrd Order (12–16) are being formed (see explanation in text) in all the exocœles.

arrangement of the muscle banners on the 12 mesenteries now present is such as to group them into the six primary pairs characteristic of hexactinian symmetry. This agrees with the results furnished by the latest stages investigated by Appellöf (1. p. 82).

Next appears a pair of mesenteries in *each lateral exocœle* (No. 7 in text-figs.), and a little later another pair (No. 8 in text-figs.) in *each ventral exocœle*. These four new pairs, though they belong to what may be called the 2nd developmental cycle, grow rapidly and take rank with the six primary pairs, the result being that ten pairs of mesenteries of the Ist Order are produced. Meantime a pair of additional mesenteries has begun to form in each dorsal exocœle (No. 9 in text-figs.). These are really the last of the 2nd developmental cycle, and their growth is slow. 3rd cycle mesenteric pairs (Nos. 10, 11 in text-fig. 5) next form in the remaining 8 exocœles and growing relatively quickly, take rank with the two pairs last named as mesenteries of the IInd Order. There are now 20 exocœles, and in each of these a new mesenteric pair (Nos. 12–16 in text-fig. 5) appears producing the 20 pairs of the IIIrd Order. It will be seen that, properly speaking, four of these pairs (Nos. 12–13) belong to the 3rd cycle, and the remainder to the 4th cycle. There are now 40 exocœles and in each of these a new mesenteric pair appears, 8 of these pairs belonging to the 4th and the remainder to the 5th developmental cycle, the whole forming the mesenteries of the IVth Order.

In the text-figs. appended, the first twelve mesenteries and the succeeding mesenteric pairs are numbered in the order of their formation. It will be seen that the mesenteries of the IInd, IIIrd, and IVth Orders tend to appear earliest in the dorsally placed exocœles. This is natural since the mesenteries of these exocœles belong to earlier cycles than those which apparently correspond with them in the other exocœles.

Boveri (**2**. p. 496) conjectured that the decamerous symmetry of *Tealia* arose by the formation of an additional pair of Ist Order mesenteries in each dorsal and ventral primary exocœle. He based this conjecture on sections of an undetermined larva obtained from the Naples Station. Faurot (**5**) states definitely that in *Tealia felina* Linn. (= *Tealia crassicornis* Gosse, *i. e.*, the shore Urticina) the four additional Ist Order mesenteric pairs arise in the dorsal and lateral primary exocœles. His description and figures bear out this statement fully, but it is to be noted that the youngest specimen he examined had already 28 tentacles. Assuming him to be right, then, in spite of superficial resemblances, there is a deep-seated developmental difference between *Urticina coriacea* and *Urticina crassicornis* which will certainly make them take rank as distinct species. Material is being collected for a revisal of his work on this point.

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2. Boveri, Th.—" Ueber Entwickelung u. Verwandschaftsbeziehungen der Aktinien." Zs. Wiss. Zool. xlix. 1889–90, pp. 461–502 (see specially p. 496).
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5. Faurot, L.—" Études sur les Actinies." Arch. Zool. Expér. et Génér. iii. 1895, pp. 43–262 (see specially pp. 172–191).
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32. The Ciliation of the Leptomedusan *Melicertidium octocostatum* (Sars). By JAMES F. GEMMILL, M.A., M.D., D.Sc.

[Received August 18, 1919: Read November 18, 1919.]

(Text-figure 6.)

Few hydromedusan gonophores have radial and ring canals wide enough to allow the action of the ciliated lining of these channels to be adequately studied. *Melicertidium* is an exception, and now that the importance of primary functions in relation to form is more and more recognised, the following details cannot fail to be of interest. (The adult medusa has eight radial canals along which the gonads are developed as eight somewhat prominent and sinuous ridges projecting into the sub-umbrellar cavity. See E. T. Browne, Proc. Roy. Soc. Edinb., 1905, p. 72, and also a forthcoming paper by the author on the Life History of *Melicertidium*.)

INTERNAL SURFACES.

1. *Stomach lining.*—Currents . . . . outwards or centrifugal from middle point of roof, and inwards or centripetal (*i.e.*, towards manubrial junction) along floor.
2. *Lining of manubrial canal.*—Currents . . . . weakly upwards (from the mouth-opening) all round, even in the radial grooves. This is different from what obtains in *Aurelia* where the radial grooves serve as channels exhalant from the stomach.
3. *Lining of radial canals.*—Currents . . . . strong, centrifugal (*i. e.*, from stomach towards ring canal along roof (exumbrellar surface) of each canal), and centripetal (*i. e.*, towards stomach) along the floor of each canal.
4. *Lining of ring canal.*—Currents . . . . confused, causing mixing, but on the whole there appears to be a flow clockwise (as viewed from the aboral side) along the floor of the canal over the openings into the tentacle cavities, and a converse flow along the opposite wall of the canal. An inward and an outward current may be noted on opposite sides of the opening of each tentacle cavity into the ring canal.

EXTERNAL SURFACES.

1. *Exumbrellar surface.*—Ciliation absent.
2. *Sub-umbrellar surface.*—(*a*) Along the projecting edges of the gonads there is strong ciliation upwards (*i. e.*, towards the manubrial region); (*b*) along the sides of the gonads the currents are towards the projecting edges but

slanting upwards and thus feeding the currents noted under (*a*); (*c*) in the spaces between the gonads ciliation is absent except towards the centre of the bell where it is feebly upwards (*i.e.*, towards the manubrial junction); (*d*) below the floor of the stomach the ciliation is strong and inwards towards the manubrium, the surface of which is likewise strongly ciliated in the direction of the mouth-opening.

3. *Tentacles.*—The tentacles show weak ciliation from their attached to their free ends, except on their inner sides near their bases where they are ciliated more strongly and in the opposite direction.

Text-figure 6.

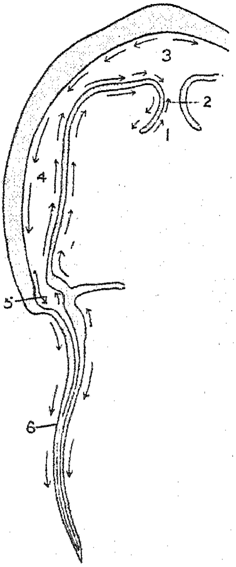

Diagram (vertical section) to illustrate ciliation of *Melicertidium*. The arrows indicate the direction of the ciliary currents. See explanation in text.

1, Mouth-opening; 2, cavity of manubrium; 3, stomach; 4, radial canal; 5, ring canal; 6, tentacle.

We may judge that the ciliation of the gastrovascular lining subserves in the first place the mixing and transportation of food, and that it is also capable of aiding the ingestion of small food particles and the evacuation of the sexual products through the mouth. The ciliation of the sub-umbrellar surface will gather small food particles towards the mouth-opening.

Since the tentacles are often found inturned into the umbrellar cavity, and even with their ends projecting into the mouth, we may infer that their ciliation will also assist, however slightly and intermittently, the important business of food gathering.

So far as I know, the only author who has investigated the direction of the ciliary currents in hydroid medusæ is Boehm (Jen. Zs. Natw. xii. 1878, p. 108), and what he states in this connection is that the currents are always from stomach to ring canal, and that he has not been able to make out ciliary activity in the roof of the latter.

Reference may be made to the following recent papers on ciliation in other marine animals:—

CARLGREN, O.—Biol. Centralbl. xxv. 1905, pp. 308–322 (Actinians, Madreporarians).
ORTON, J. H.—Journ. Mar. Biol. Assoc. U.K. ix. 1912, pp. 144–478 (Ascidians, Molluscs).
ORTON, J. H.—*Ibid.* x. 1913, pp. 19–49 (Amphioxus, Ascidians, Molluscs).
GEMMILL, J. F.—Proc. Zool. Soc. Lond. 1915, pp. 1–19 (Starfish).
WIDMARK, E. M. P.—Zs. Allg. Phys. Jena, xv. 1913, pp. 33–48 (*Aurelia aurita*).
GEMMILL, J. F.—Proc. Zool. Soc. Lond. 1919, pp. 263–265 (Ctenophore).

EXHIBITIONS AND NOTICES.

October 21st, 1919.

Prof. E. W. MacBride, F.R.S., F.Z.S., Vice-President, in the Chair.

The Secretary read the following Reports on the Additions made to the Society's Menagerie during the months of June, July, August, and September, 1919:—

June.

The registered additions to the Society's Menagerie during the month of June were 355 in number. Of these 267 were acquired by presentation, 11 were deposited, 7 were received in exchange, 66 were purchased, and 4 were born in the Menagerie.

The following may be specially mentioned:—

2 Cheetahs (*Cynælurus jubatus*), from Berbera, Somaliland, deposited on June 26th.

2 Pandas (*Ælurus fulgens*), born in the Menagerie on June 26th.

A collection of birds from Gambia, West Africa, consisting of Fire-Finches, Quail-Finches, Weavers, and two Black-shouldered Kites, presented by Dr. E. Hopkinson, D.S.O., on June 19th.

2 Bateleur Eagles from Berbera, Somaliland, presented by G. F. Archer, C.M.G., on June 26th.

2 Glaucous Gulls, hatched in the Menagerie on June 27th.

July.

The registered additions to the Society's Menagerie during the month of July were 343 in number. Of these 37 were acquired by presentation, 32 were deposited, 3 were received in exchange, 238 were purchased, and 33 were born in the Menagerie.

The following may be specially mentioned:—

1 Hippopotamus (*Hippopotamus amphibius*), ♂, born in Amsterdam, purchased on July 16th.

1 Yak (*Bos grunniens*), ♀ (Tibet), deposited on July 1st.

1 White-bearded Gnu (*Connochætes albojubatus*), born in the Menagerie on July 30th.

1 Père David's Babbler (*Pterorhinus davidi*), from North China, new to the Collection, deposited on July 31st.

2 Greenish Hangnests (*Pseudoleistes virescens*), and 1 Yellow Troupial (*Agelæus flavus*), from Argentina, presented by M. Jean Delacour on July 18th.

1 Ross's Plantain-eater (*Musophaga rossæ*), 1 Bare-faced Fruit-Pigeon (*Vinago calva*), and 2 Grant's Francolins (*Francolinus

granti), from British East Africa, presented by Dr. Van Someren on July 22nd.

A collection of North-American Reptiles, including 2 Horned Lizards (*Phrynosoma cornutum*), 2 Bull Snakes (*Pituophis sayi*), 2 Testaceous Snakes (*Zamenis flagelliformis*), and 3 Western Diamond Rattlesnakes (*Crotalus atrox*), purchased on July 28th.

August.

The registered additions to the Society's Menagerie during the month of August were 68 in number. Of these 29 were acquired by presentation, 9 were deposited, 3 were purchased, and 27 were born in the Menagerie.

The following may be specially mentioned:—

1 Leopard (*Felis pardus*), ♀, from Kismayu, British Somaliland, presented by H.M.S. 'Hyacinth' on August 6th.

2 Young Indian Elephants (*Elephas maximus*), from Assam, deposited on August 23rd and 25th.

1 Kilima-Njaro Sunbird (*Nectarinia kilimensis*), from Uganda, new to the Collection, deposited on August 9th.

2 Elephantine Tortoises (*Testudo elephantina*), from the Seychelles, presented by H.E. Lt.-Col. Sir Eustace Fiennes, Bt.

September.

The registered additions to the Society's Menagerie during the month of September were 153 in number. Of these 33 were acquired by presentation, 22 were deposited, 91 were purchased, and 7 were bred in the Menagerie.

The following may be specially mentioned:—

1 Red-bellied Cercopitheque (*Cercopithecus erythrogaster*) (Lagos), purchased on September 17th.

1 Black Mangabey (*Cercocebus aterrimus*) (Congo), purchased on September 9th.

2 Red-cheeked Ibises (*Comatibis eremita*), from Birijik, Upper Euphrates, new to the Collection, presented by Capt. E. H. Buxton, on September 6th.

Mr. Oldfield Thomas, F.R.S., exhibited three interesting Mammals obtained by Dr. Aders, F.Z.S., in Zanzibar: namely, an example of *Cephalophus adersi*, a recently described new species; an example of *Colobus kirki*, which until lately was supposed to be almost extinct, and a specimen of a rare Insectivore belonging to the genus *Petrodromus*.

Discussion on The Zoological Position and Affinities of Tarsius.

Dr. A. Smith Woodward, F.R.S., in opening a "Discussion on the Zoological Position and Affinities of *Tarsius*," said:—

The small mammal *Tarsius*, though technically a lemur, exhibits so many anatomical resemblances to the higher anthropoids that it proves to be one of those solitary links between groups which palæontologists welcome as "living fossils." It survives only in the Philippines and in the Indo-Malayan region, which furnishes some other primitive mammals, among which may be specially mentioned the ancestral ruminant *Tragulus*. Apart from its enlarged eyes and its highly specialised jumping feet, it might well be regarded as belonging to the earliest Tertiary period, the Eocene.

Among Eocene fossils already known both from Europe and North America, there are numerous small jaws with a dentition much resembling that of *Tarsius*. Some of these may belong to primitive insectivores, carnivores, and ungulates, which were not well differentiated at the beginning of the Tertiary epoch; but complete skulls of *Anaptomorphus* and *Notharctus* from the Lower and Middle Eocene of North America, and others of *Necrolemur* from the Upper Eocene or Oligocene of France, are essentially identical with the skull of *Tarsius*. The greater part of the skeleton of *Notharctus* has also been discovered, and the hind foot differs from that of *Tarsius* only in the shortness of the calcaneum and navicular. A survey of all the known fragments of Eocene lemurs suggests that they were generalised forms, from which both the modern lemurs and the anthropoids may have arisen.

For the latest information reference may be made to papers by Dr. W. K. Gregory in Bull. Geol. Soc. America, vol. xxvi. pp. 419–446 (1915), and Bull. Amer. Mus. Nat. Hist. vol. xxxv. pp. 258–271 (1916).

Prof. G. Elliot Smith, F.R.S.:—Twelve years ago in a letter to 'Nature' (May 2, 1907, vol. 76, p. 7) I explained my reasons for thinking that the analysis of the Primates which gave most natural expression to the known facts involved the splitting up of the Order into three subdivisions of subordinal rank, of which the central Suborder includes *Tarsius* alone of the living members, in addition to the extinct Eocene families Anaptomorphidæ and Microchœridæ. This mode of subdivision had been suggested by Dr. Gadow in 1898.

My presidential address to Section H of the British Association in 1912 was devoted, in the main, to the discussion of the part played by the Tarsioidea in the Evolution of Man, and the discussion of the significance of the persistence in Man and *Tarsius* of so many generalised features, which had been modified in most other Primates, and even more profoundly in most mammals of other Orders. In that address I attempted to explain the preservation of a generalised structure, in association with exceptional efficiency, as a token of the fact that Man's ancestors were able to survive and maintain the plasticity of a generalised structure and the functional adaptability that goes with it, in virtue of the fact that they were cultivating their intellectual powers rather than specialising for one particular kind of life. Their nimbleness of mind and agility of action enabled them to adapt themselves to a great variety of changing circumstances without sacrificing the generalised structure of their limbs; so that, when their opportunity came, they still had the mental and bodily plasticity to take advantage of it, and acquire the dominant position in the animal kingdom. The Lemurs and most Monkeys sacrificed their chances of attaining such pre-eminence when they adopted specialisations of structure and of habits to avert the risk of extinction. *Tarsius* represents the phylum whose progress was brought to a sudden stop in Eocene times by an over-development of, and an exaggerated reliance upon, those specialisations of vision and its cerebral instruments which were responsible for the differentiation of the Tarsioidea from the Lemuroidea, and gave impetus to those developments which produced the Anthropoidea from one of the Tarsioid families. But *Tarsius* was able to escape extinction only by adopting the safe nocturnal habits which also played a part in sparing the Lemuroidea.

The evidence upon which my own views were based was primarily a detailed examination of the brain in the Primates, the first results of which were submitted to the Linnean Society on March 6, 1902*.

In that memoir I explained how conclusively the structure of the brain demonstrates (*a*) that the Lemuroidea differ from mammals of all other Orders in presenting cerebral features that are distinctive of the Primates; (*b*) that *Tarsius* has a brain which, in most respects, closely resembles, and is no better developed than, that of such Lemuroids as the Galaginæ; but (*c*) that it reveals a reduction of the olfactory areas and an expansion and precocious development of the visual cortex, which represent the commencement of specialisations foreshadowing the emergence of distinctively Simian features.

This evidence is so precise and conclusive and its significance so unmistakable that those who have attempted to exclude the Lemuroidea from the Primates have perforce been driven to repress all reference to the brain, the organ which above all others has been responsible for raising the Primates to the rank expressed in their Ordinal name, and most plainly gives expression to the distinctive features of the Order. For the outstanding characteristic of Man is the range of his intellectual abilities, and of the Order to which he belongs the nature of the instrument—the cerebral structure—which made possible the emergence of such extensive powers of discrimination in one of its members.

In each of the mammalian Orders there is a distinctive mode of folding of the cerebral cortex that is due to the relative development of the different physiological areas, and especially to the rate and order of their growth during fœtal life. The ground plan of this pattern of the sulci was already laid down in the Eocene ancestors of most of the Orders; and it is so peculiar to each of them as to afford a sure criterion of the right of any creature to be regarded as a true member of an Order. The fact that the Lemuroidea strictly conform in every respect to this distinctive test of membership of the Primates is conclusive proof of their right to be included in the Order.

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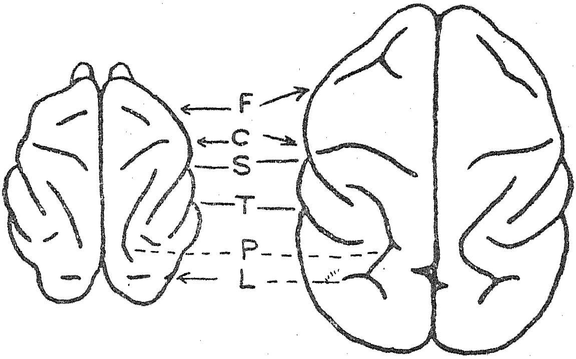
* "On the Morphology of the Brain in the Mammalia, with Special Reference to that of the Lemurs, Recent and Extinct," Trans. Linn. Soc. of London, 2nd Series, Zoology, vol. viii. p. 319.

Text-figure 1.



Perodicticus. *Pithecia.*

A comparison of the cerebral hemispheres of a Lemuroid (*Perodicticus*) and a New-World Monkey (*Pithecia*)—natural size.

F.—Inferior frontal sulcus.
C.—Central sulcus.
S.—Sylvian fissure.
T.—Superior temporal sulcus.
P.—Postcentral (intraparietal) sulcus.
L.—Lunate sulcus.

In the Primates it was the precocious expansion of the brain and the simultaneous cultivation of the visual, auditory, tactile, and motor areas of the cerebral cortex that first differentiated the earliest Primates from all other mammals, and provided them with the germs of the capabilities and the means of attaining the supreme position expressed in the name of the Order.

The pattern formed by the cerebral sulci, equally in the Lemuroidea and the Anthropoidea (see text-figure), is the direct expression of the factors I have already mentioned. The precocious expansion of the visual cortex causes this area to become folded along its axis, so that the major portion of the area striata is bent in to form the retrocalcarine furrow in a way that is peculiarly distinctive of the Primates, and is found equally in all three Suborders*, but in no other mammal. The simultaneous expansion of the tactile and auditory areas leads to the development of the equally distinctive Sylvian fissure (text-figure, S.), which is found in no other Order, except in a somewhat modified form in certain Chiroptera and Edentata. This characteristic fissure is found in all the Lemuroidea and Anthropoidea, but in *Tarsius* the enormous size of the orbits stretches the brain and tends to erase this characteristic fold of the cortex. The great expansion of the sensory and motor areas is responsible for the development of the central sulcus in *Perodicticus* (see text-fig., C) and certain of the Indrisinæ; but in most of the Lemuroidea it is represented only by two slight puckers or is absent altogether, as in *Tarsius*, the Hapalidæ, and some of the Cebidæ (*Aotus* and *Callithrix*). But this sulcus is so peculiarly distinctive of the Primates that its occurrence in some of the Lemuroidea is of the utmost value as an indication of the affinities of the Suborder. The inferior frontal (text-figure, F.), superior temporal (T.), lunate (L.), and orbital sulci complete the picture of the Primate plan; and they not only reproduce in the Lemuroidea the same form and grouping as in the Cebidæ (see text-figure), but are subject to the same variations. Specially significant is the fact that the postcentral (so-called "intraparietal") sulcus in *Nycticebus* and some of the Indrisinæ shows a tendency to fuse with the Sylvian fissure, which produces the same peculiar pattern that is found among the Cebidæ in *Chrysothrix*, *Aotus*, *Alouatta*, and at times in *Lagothrix*.

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* I have discussed this at some length in my Linnean memoir (*op. cit. supra*).

Everyone who is acquainted with the wide divergence between the fissural pattern of the Primates and those of other Orders cannot fail to be impressed with the completeness of the identity between the Lemuroidea and the Anthropoidea in respect of these features, and of its significance as positive evidence of kinship.

But these superficial resemblances are merely the outward expression of a deep-seated structural and functional identity which demonstrates beyond any possibility of mistake that the Lemurs are primitive members of the Order Primates. Working in conjunction with the late Dr. Page May and Professor W. H. Wilson, I made an experimental examination of the reactions of the cerebral cortex in *Loris* and *Lemur* *, and not only confirmed the conclusions suggested by the study of the morphology of the cortex, but also obtained results which showed a differentiation of cortically-controlled movements much superior to that of any other mammals with the exception of the Anthropoidea. The researches of Vogt subsequently (1906) confirmed our results. But the evidence afforded by the minute structure of the brain is even more decisive. In the 'Transactions' of this Society some years ago (May 1908, Vol. xviii. p. 175) I referred to my histological studies of the Prosimian cerebral cortex and their general significance. Later in the same year the account was published of a much more detailed examination of the Lemur's cortex than I had made †.

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* See Report of the British Association, 1904, p. 760.

† K. Brodmann, "Die cytoarchitektonische Cortexgliederung der Halbaffen," Journal für Psychologie und Neurologie, Bd. x, 1908, p. 287.

Brodmann not only examined (in Vogt's laboratory) the microscopic structure of the Lemur's cortex, but also made an elaborate comparison between it and the cortex of the Apes and a considerable series of other mammals*. He arrived at the conclusion that in the arrangement of its cells and fibres the Lemur's cortex reveals "weitgehende Uebereinstimmung mit den Primaten [*i. e.* Simiæ], in einzelnen jedoch Abweichungen mancher cytoarchitektonischer Typen teils im Sinne einer niederen, teils aber auch im Sinne einer höheren Differenzierung aufweist."

Brodmann did not examine the brain of *Tarsius*; but my own studies enable me to say that its visual cortex is not only more extensive than that of the Lemuroidea, but also more highly differentiated and more like that of the Apes. The other regions of the cortex, however, conform much more closely to the corresponding areas in the Lemuroidea, both in extent and in structure, than to those of the Apes.

The Tarsioidea seem to have become differentiated from the Lemuroidea by a reduction of the face, which permitted the much fuller development of stereoscopic vision. This in turn stimulated the higher specialisation of the visual cortex and provided the guidance for the performance of movements of a much greater skill and precision. It was the cultivation of these powers that brought one branch of the Tarsioidea to Simian rank.

Not content with the recognition of the fact that the Apes were derived from the Suborder Tarsioidea, some of those who are taking part in this discussion want to promote *Tarsius* to the full status of an Ape. This is an unwarrantable claim. The anatomy of every part of the body, and more particularly of the brain, reveals the extent of the profound difference between the Anthropoidea and the Tarsioidea. On the present occasion I shall not attempt to enumerate all the criteria of a true Ape, and shall refer only to one point (which, however, is of fundamental importance as a distinctive feature between the Anthropoidea and the other two Suborders of the Primates). In the true Apes all the great cortical areas to which I have already referred (visual, auditory, tactile, and motor) are very much larger and more highly differentiated than they are either in the Tarsioidea or the Lemuroidea. But, in addition, the relatively insignificant parietal, temporal, and frontal "association areas" of the Prosimiæ have undergone so much expansion that the brain of a real monkey is, at least, about three or four times the bulk of that of a Tarsioid or Lemuroid of the same size; and these overgrown territories have also become highly differentiated and specialised. In my Linnean memoir (1902), to which I have already referred, the data for comparing the size of the brain in different mammalian Orders has been set forth, so that I need refer here only to one relevant point.

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* 'Vergleich. Lokalisationslehre der Grosshirnrinde,' 1909.

Comparing *Nycticebus* and *Pithecia* as representatives of the Lemuroidea and Cebidæ of approximately the same size (each weighing about 500 grm.), it is found that the brain of the former varies in weight from 7·72 to 8·18 grm., whereas the monkey's brain ranges from 22 to 36·2 grm. In other words, the lowly Platyrrhine has from three to four times as big a brain as the Lemuroid. To one who studies the meaning of the size of the cerebral cortex in the different mammalian Orders, and realises the significant rôle such expansion of the brain has played, ever since Eocene times, in the evolution of the higher mammals, and especially of the Primates, it will be evident that a vast chasm separates the monkeys from the Lemurs. Now Eugen Dubois states * that the proportion of brain to body in *Tarsius* is not appreciably different from that of *Nycticebus*. In other words, judged by this fundamental test, *Tarsius* is sharply differentiated from the Apes and occupies a rank not unlike that of a Lemur. As Cope pointed out more than thirty years ago, the brain of *Tarsius* is not appreciably bigger than that of the Eocene *Anaptomorphus* †.

The ancestors of *Tarsius*, in fact, fell out of the race for intellectual supremacy in Early Eocene times and ceased cultivating their cerebral organs. Eventually, like the Lemurs, they had to adopt nocturnal habits to avoid the risk of extinction. At the same time another branch of the Tarsioids was cultivating more highly skilled movements, and acquiring greatly enhanced powers of discrimination and ability to profit from experience. In course of time—and probably long before the close of the Eocene—this particular family of big-brained Tarsioids was transformed into real monkeys and became the ancestors of the Anthropoidea.

Before leaving this aspect of the problem, and while emphasising the fact that so far as size of brain is concerned *Tarsius* is on the same level as the Lemuroids, it is important to remember that at the commencement of the Eocene period the representatives of both the Lemuroidea and the Tarsioidea (and no doubt their common Prosimian ancestors) were equally distinguished from all other Orders by their relatively large brain. Both, in fact, shared alike in the fundamental structural change that brought the Primates into being. Even the modern Lemuroids, poorly equipped as they are in brain-substance as compared with the Apes, are better off in this respect than members of similar size of any other Order. Thus in the Carnivora, which come next to the Primates in respect of size of brain, it is found that in animals of the same size as Lemurs the brain is about 1/100th (or less) of the body-weight, whereas in Lemurs it is usually about 1/70th, but may rise to 1/60th or more. But in a monkey of similar size it is 1/20th or even 1/15th of the body-weight. But we cannot on these grounds exclude the Lemuroidea from the Primates, because the Tarsioidea are no better off than the Lemurs so far as the quantity of brain is concerned.

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* 'Proceedings of the Fourth International Congress of Zoology,' Cambridge, 1898, p. 91.

† E. D. Cope, "The Lemuroidea and the Insectivora of the Eocene Period of North America," American Naturalist, May 1885, p. 467.

Discussing the size of the cranial cavity of *Anaptomorphus*, he wrote :—"The brain and its hemispheres are not at all smaller than those of *Tarsius*. . . . This is important in view of the very small brains of the flesh-eating and ungulate Mammalia of the Eocene period as yet known. In conclusion, there is no doubt but that the genus *Anaptomorphus* is the most Simian lemur yet discovered, and probably represents the family from which the anthropoid monkeys and men were derived."

The remarkable claim has been made that all the resemblances between the Lemuroidea and the other Primates were due to the fact that the former are primitive mammals and the Tarsioidea and Anthropoidea generalised creatures that have preserved many primitive features; or that they were the result of convergence in animals leading similar modes of life. The former statement can be ruled out of the argument at once, because the brain of the Lemuroidea is definitely specialised in the manner I have already described. Nor can the mode of life be regarded as the explanation of the likenesses, because such arboreal animals as the Tree-Shrews, Squirrels, *Galeopithecus*, et cetera, present none of the numerous Primate features seen in the Lemur's brain. The fashionable and seriously overworked doctrine of convergence is also a mere evasion of the real issue. There is abundant evidence of convergence in the three Suborders of the Primates, but it is clearly the expression of the tendency of similar traits to develop in the various descendants of the same common ancestor, and therefore can hardly help those who refuse to admit the close connexion of the Lemuroidea with the other Primates. Henry Fairfield Osborn has emphasised the fact that "the *same* results appear independently in descendants of the *same* ancestors"[*]. No more admirable illustrations of this principle could be found than those elicited in the comparison of the Lemurs and Apes, in the various individuals and species of which peculiar conformations of brain, arrangements of muscles and arteries, form of bones, structure of viscera and genital organs, which occur in no other mammals, tend to reveal themselves in both the Lemurs and the Apes. As illustrations of these striking demonstrations I might refer to the central sulcus of *Perodicticus*, the tendency of the Sylvian fissure to fuse with the intraparietal, which is found in *Nycticebus* and among the Apes in many of the Cebidæ[†]. Note also the striking likenesses in the temporal bone and the course of the internal carotid in *Tarsius* and the Lorisiformes, the tarsus of the Galaginæ and *Tarsius*, and the similar variations in the lacrymal region of the skull in Lemurs and Apes which Dr. Forsyth Major has described in the 'Proceedings' of this Society. These are, for the most part, illustrations of similar peculiarities developed independently in divergent descendants of the same common ancestor.

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[*] "The Four Inseparable Factors of Evolution." Science, N. S., vol. xxvii. January 24, 1908, p. 150.

[†] See my account in the 'Catalogue of the Museum of the Royal College of Surgeons.'

Ever since the time of Burmeister (1846) everyone who has studied *Tarsius* has admitted its peculiarly distinctive position, which Burmeister himself described so clearly when he claimed it as a connecting-link between the Lemurs and the Apes ("Uebergangslied, wenn auch gerade nicht eins der auffallendsten und merkwürdigsten"). He clearly recognised its generalised character and its resemblances both to the Insectivora and to the higher Primates, and epigrammatically summarised his conclusions in these words:—"Aber *Tarsius* ist nicht mal ein Affe, er ist vielmehr nur ein Halbaffe"[*]. It is generally admitted that *Tarsius* is a remarkably generalised creature which in many respects is akin to the Menotyphlous Insectivora, and has persisted with extraordinarily little change from the beginning of the Eocene period. But it is also recognised that every part of its anatomy, brain and skull (including the developmental history of the skull[†]), face and rhinarium, muscles and viscera, genitalia and mode of placentation, reveals its affinity to the higher Primates and affords evidence of its differentiation from the Lemuroidea.

Hence we are concerned in this discussion, not so much with the facts of the case, which are admitted, as with the right perspective in which they should be viewed, and their significance estimated and expressed in classification. This cannot be done merely by enumerating lists of differences between *Tarsius* and the Lemurs or resemblances of the former to the Apes, especially if all the evidence that lends support to the reality of the kinship of the Lemurs and the other Primates, and that indicates the lowly rank of *Tarsius*, is suppressed. By means of such methods of special pleading a case might be stated for the view that the whale was a fish, if care were taken to omit all reference to the mammalian characters of the Cetacea. Yet the facts that establish the right of the Lemurs to be regarded as Primates are no less definite than those that make the whale a mammal. It reveals a singular lack of logic to exclude the Lemurs from the Primates because they are not Tarsii. One does not deny the rank of Carnivora to dogs because they are not bears!

In 1830 Wagler claimed that the Lemurs should be put into an Order (Lemures) distinct from the Apes (Simiæ). Then in 1846 Burmeister with his wider knowledge and clearer insight restored the true perspective, as I have already explained. But since then a vast literature has grown up as the result of the repeated reopening of these old controversies. Wagler has had many followers, such as Gratiolet, Gervais, Milne-Edwards,

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[*] H. Burmeister, 'Beiträge zur Kenntniss der Gattung *Tarsius*,' 1846, p. vi.

[†] Eugen Fischer, "On the Primordial Cranium of *Tarsius spectrum*," Koninklijke Akademie van Wetenschappen te Amsterdam, Proceedings of November 22, 1905, p. 400, "exceedingly close relationship of the developing cranium of *Tarsius* and that of the ape and man" and "the striking resemblance between this type of skull and that of reptiles."

Hubrecht, and Max Weber, in his attempt to remove the Lemurs into an Order apart from the other Primates: but the fallacy of the arguments brought forward in support of such views has been repeatedly exposed [*]. In view of the much more extensive and precise knowledge of comparative anatomy, embryology, and palæontology that is now available, these claims to exclude the Lemuroidea from the Primates have even less justification than in the past, and can only be given a plausible appearance by special pleading of a desperately biassed kind.

The zoological rank and affinities of no mammal are more precisely determined than are those of *Tarsius*. The evidence presented in Filhol's memoir [†], published forty-five years ago, clearly demonstrated that the Eocene ancestors of the Lemurs were closely akin to the contemporary forerunners of the Tarsioids, and mention has already been made of Cope's recognition (in 1885), not only of the derivation of the Apes from the Anaptomorphidæ, but also of the human likenesses which he expressed by giving the specific name *homunculus* to a *Tetonius*. But any lingering doubts on this subject have been dispelled by the recent papers published by members of the staff of the American Museum of Natural History [‡].

The evidence of anatomy and palæontology is thus unanimous in support of the right of the Lemuroidea to be included in the Primates. Nevertheless, the cleavage between *Tarsius* and the Lemuroidea is so great as to establish the right to a separate Subordinal rank for the former. The fact that its ancestors parted company with those of the Lemuroidea so early as Paleocene or even perhaps Cretaceous times affords strong corroboration of the claim to put it into a distinct Suborder Tarsioidea. I have already referred to the unjustifiable claim that the Tarsioids are already monkeys and ought to be put into the Suborder Anthropoidea. Those who argue in this illogical way might perhaps appreciate the fallacy underlying their claims by studying an analogous case. The Cynodonts are a group of very primitive fossil reptiles which are distinguished from all other reptiles (including all the surviving members of their Class) by a large number of features which they share with Mammals. Moreover, it is now generally admitted that the Mammalia were derived from one of the Cynodont families. Yet no palæontologist, so far as I am aware, has been reckless enough to suggest that the Cynodonts should be removed from the Class Reptilia and promoted to the Class Mammalia. But those who want to remove *Tarsius* from it slowly station and elevate it from Prosimian to Simian rank are making a claim that is as preposterous as the hypothetical parallel just suggested. In some respects the analogy may seem inconsistent with the course I have adopted here. It may perhaps be argued that, just as the Cynodonts are still retained in the Class Reptilia, so the Tarsioids ought to be retained in the Suborder Lemuroidea. Matthew and Gregory have, in fact, recently (*op. cit. supra*) reaffirmed their belief in this traditional method of subdividing the Primates; and there is unquestionably a good deal to be said for preserving the term Prosimiæ. But the problem differs from that of the Cynodonts in that we are now discussing the grouping of the constituent parts of a single Mammalian Order, whereas the Cynodont problem involves the interrelationships of two Vertebrate Classes. The depth of the cleavage between the Tarsioids and the Lemuroids and the remarkable affinities of the former to the Anthropoidea signifies that the Tarsioidea occupy a position definitely intermediate between the other two groups of Primates, which finds most natural and most convenient expression if a separate Suborder is made to include the Tarsioids. This is no mere compromise between the extremists on the two sides, but the arrangement which the whole trend of research since the time of Burmeister has made more and more insistent and necessary.

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[*] As, for example, by
Sir William Turner, "On the Placentation of the Lemurs," Philosophical Transactions of the Royal Society, vol. 166, pt. 2, 1876, p. 569 (who gives the earlier bibliography),
and
Charles Earle, "The Lemurs as Ancestors of the Apes," Natural Science, vol. x., May 1897, p. 309:
also "On the Affinities of *Tarsius*: a Contribution to the Phylogeny of the Primates," American Naturalist, vol. xxxi., July 1897, p. 569, and August 1897, p. 680.

[†] H. Filhol, "Nouvelles observations sur les Mammifères des Gisements de Phosphates de Chaux," Annales des Sciences Géologiques, T. v. Pl. 7 (1874).

[‡] W. D. Matthew and Walter Granger, "A Revision of the Lower Eocene Wasatch and Wind River Faunas," Bull. American Museum of Natural History, vol. xxxiv. (1915). William K. Gregory, "On the Relationship of the Eocene Lemur *Notharctus* to the Adapidæ and the other Primates" and "On the Classification and Phylogeny of the Lemuroidea," Bulletin of the Geological Society of America, vol. xxvi., Nov. 1915, p. 419; and "Studies on the Evolution of the Primates," Bulletin of the American Museum of Natural History, vol. xxxv., June 1916, p. 239.

If the exact status and affinities of the Tarsioidea as Eocene Prosimiæ and their little-altered survivors has been definitely established, the recent discoveries* of the Early Oligocene genera *Parapithecus* and *Propliopithecus* in the Egyptian Fayûm have no less definitely settled the relationships of the Suborder to the Anthropoidea. *Parapithecus* retains sufficient of the primitive traits to establish the truth of the Tarsioid ancestry of the Apes, but it also provides evidence which can only be adequately explained on the supposition that the transformation of a Tarsioid into a primitive Ape must have occurred before the close of the Eocene. For in the lowest Oligocene the primitive ape *Parapithecus* is found in association with *Propliopithecus*, which had developed far beyond the stage represented by the former and become a real Anthropoid Ape. *Parapithecus*, then, at the beginning of the Oligocene, must have been a survival from a still earlier period, *i. e.* there were real monkeys in the Eocene. I do not suppose that anyone will refuse to admit the certainty of the derivation of the tailless Anthropomorpha from tailed Catarhines; but the early development of true Simiidæ shows that the differentiation of the Old-World Apes into Cercopithecidæ and Simiidæ must have occurred almost immediately after the Catarhines themselves came into being.

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* M. Schlosser, "Beiträge zur Kenntniss der Oligozänen Landsäugetiere aus dem Fayum (Ägypten)," Beiträge zur Pal. u. Geol. Österreich-Ungarns u. d. Orients, Bd. xxiv, 1911, p. 52.

Anyone who conscientiously investigates the anatomy of the Platyrrhine Apes, and attempts to interpret the vastly complicated series of cerebral transformations that were necessary to convert a Tarsioid into a monkey, must be forced to admit that this did not happen twice, but that the Platyrrhines and the Catarhines were derived from a common stock, some archaic Ape more primitive and more Tarsioid even than *Parapithecus*, and at a time long before the close of the Eocene period. The history of the ancestors of the Anthropoidea thus becomes clear.

In North America (which was clearly the home of the Order Primates) the Lemuroidea and the Tarsioidea were differentiated from the ancestral Primate probably at the close of the Cretaceous period. At some time during the Eocene (and somewhere in the neighbourhood of America) true monkeys were differentiated from one of the Tarsioid groups. Some of these found an asylum in South America and became specialised as the Platyrrhines. But others (in Eocene times) made their way to the Old World along with the Adapid and Anaptomorphid ancestors of the Lemuroidea and Tarsioidea respectively. During this migration these primitive monkeys became transformed into Catarhines, and the remains of *Parapithecus* provide the evidence of their reality and give a hint as to their size and distinctive features.

There is one other aspect of the problem under discussion which has been fruitful of much misunderstanding. The Lemuroidea represent a lower stratum of Primate evolution than the Tarsioidea, just as the latter are on a very much lower plane than the Anthropoidea. But, while the Lemuroidea retain many features of brain, skull, face, placentation, et cetera, which are survivals from their Paleocene or Cretaceous ancestry—the earliest Primates,—during the long span of time that has elapsed since the Cretaceous period they have acquired a host of minor specialisations of structure which have modified or masked much of their original likeness to the other Primates. *Tarsius*, however, although on a distinctly higher plane of Primate development, has managed to escape extinction with fewer and slighter specialisations than the Lemurs. Hence it has retained a much more generalised and obviously primitive structure along with the germs of the features that are distinctive of monkeys.

Prof. J. P. Hill, F.R.S.

The Affinities of *Tarsius* from the Embryological Aspect.

(With Table, Plate I., and Text-figures 1–5.)

My task in this discussion * is to consider what light the facts of development throw on the question of the affinities of *Tarsius*. In furtherance of that object, I have thought it might be both useful and time-saving if I presented you with a brief summary, in the form of the accompanying comparative table (*v.* p. 490), of what I take to be the most important of the known facts relating to the development, fœtal membranes, and placentation of the main groups of the Primates. For the purposes of this discussion, I have set forth the facts relating to *Tarsius* in column 2 of the table, in order that you may the more readily compare them with those appertaining on the one hand to the Lemuroids (Lemuriformes and Lorisiformes) in column 1, and on the other to the Anthropoids in column 3. It remains to be seen in how far this tripartite mode of grouping the Primates is justifiable on embryological grounds.

The first question which arises is that of the systematic position and affinities of the Lemuroids. It is generally agreed that the Lemuroids are a lowly and in many respects primitive group, and even Hubrecht admitted that they "are in no respect a very specialised order of Mammals." The prevailing view, widely held both by comparative anatomists and palæontologists, is that they lie at the base of the Primate series; but certain authorities, notably Hubrecht, deny that they are in any way related to the other Primates. That is a view which, on embryological grounds alone, I am unable to accept.

Unfortunately our knowledge of the development of the Lemuroids is very fragmentary, but what we do know shows, in my opinion, perfectly clearly that the existing forms are no such forlorn and degenerate creatures as some would have us believe, but, on the contrary, are to be regarded as the representatives of a very old and primitive group of Mammals from which the other and higher Primates may very well have taken their origin. In their simple central type of development (the blastocyst developing free in the uterine lumen), in their mode of amnion formation (the amnion developing from folds in the presence of a proamnion), and in the mode of development and the relations generally of their fœtal membranes (in particular, in the presence of a vesicular allantois, which grows out as a free

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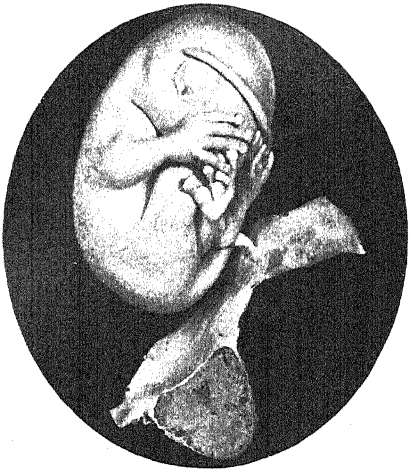
* Since the date of the discussion, I have had the opportunity, thanks to the great kindness of Dr. Dan. de Lange, Junr., Director of the International Institute of Embryology at Utrecht, of examining a uterus of *Tarsius*, containing a nearly full-term fœtus with its placenta and of preparing sections of the latter. I wish here to express my most cordial thanks to Dr. de Lange for his generosity in enabling me to examine for myself this rare and valuable material. Its study has led to some modification of the views I expressed at the meeting.



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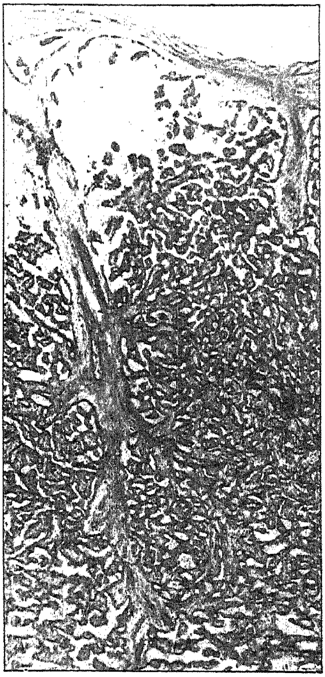

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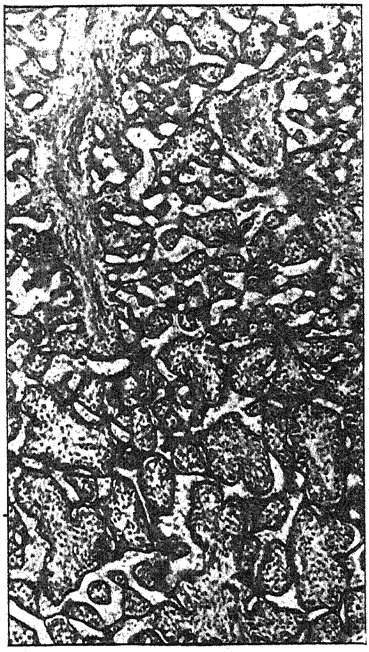

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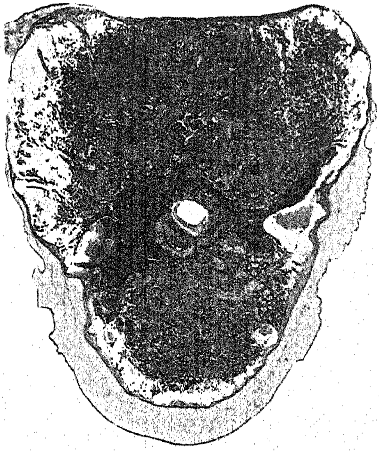


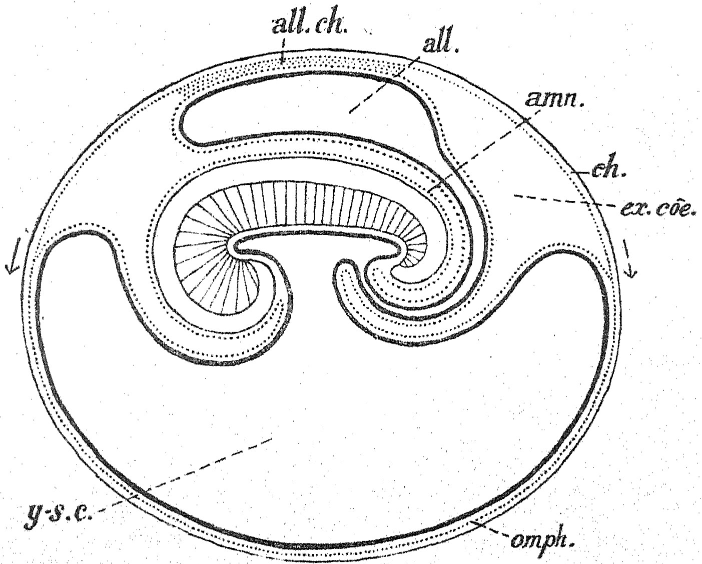
2

PLACENTATION OF *TARSIUS*.

vesicle and subsequently unites with and vascularises the entire chorion), we see features all of which we are familiar with in the development of the lower members of the Mammalian series, and all of which are, in my opinion, primitive.

Moreover, the primary relations of their fœtal membranes are precisely those which we are justified in postulating for the primitive ancestral stock from which presumably both the Didelphia and Monodelphia diverged; whilst their simple, diffuse, non-deciduate placenta (involving the loose interlocking of short villous outgrowths of the allanto-chorion with corresponding crypts of the uterine mucosa, the persistence of the uterine epithelium and of the uterine glands) is, in my view, essentially primitive, presenting us with a simple little specialised type of placenta from which the much more advanced, and presumably more efficient, arrangements in the other

Text-figure 1.



Nycticebus tardigradus. Diagram (after Hubrecht) to show the arrangement of the fœtal membranes of the early embryo. Note especially the allantois (*all.*) already fused with the chorion (*ch.*) to form a discoidal area of allanto-chorion (*all.ch.*). The arrows indicate the direction of extension of the extra-embryonal cœlom (*ex.cœ.*) into the mesoderm of the omphalopleure (*omph.*) so as to separate that into yolk-sac wall and chorion. *amn.* amnion. *y-s.c.* yolk-sac cavity.

Ectoderm (including trophoblast) is represented by a thin line, entoderm by a thick line, and mesoderm by a dotted line.

Primates may quite easily have originated as the result of adaptive specialisation in the course of evolution. Hubrecht, however, took an entirely opposite view and held that the placentation of these forms is not genuinely primitive, but had arisen from some hypothetical, more complicated form of placenta as the result of secondary reduction and degeneration; and Assheton, inclining to the same point of view, suggested that it might have been derived from a primitive Carnivore type, also by reduction. For these views, expressed in connection with particular theories of placental evolution, there is, so far as I am aware, not the slightest direct evidence.

On the other hand, the evidence derivable from a study of the development of the fœtal membranes seems to me to provide us with a perfectly definite lead. Hubrecht's observations on *Nycticebus* show that the allantois grows out into the extra-embryonal cœlom as a small stalked vesicle, just as it does in all primitive Mammals. It rapidly increases in size and already in the embryo of 4·2 mm. (G. L.) has extended over and fused with the discoidal area of chorion, which is thus transformed into vascular allanto-chorion (text-fig. 1, *all.ch.*). In later stages, following the splitting of the extra-embryonal mesoderm, it rapidly spreads and the chorion, over its entire extent, is converted into vascular allanto-chorion. With this rapid and very marked growth of the allantois are to be correlated two other occurrences to which I would direct attention: (1) the extra-embryonal cœlom rapidly extends throughout the entire extent of the mesoderm of the blastocyst wall or omphalopleure, which thus becomes split into chorion and yolk-sac wall; (2) the yolk-sac becomes established as an independent vesicle, and the yolk-sac placenta, if such temporarily exists in connection with the early embryo, becomes completely replaced by the allantoic.

These development features in the Lemuroids—viz., the establishment of a complete chorion and its early vascularisation by the rapidly growing allantois, the early formation of an extensive extra-embryonal cœlom and the separation of the yolk-sac as an independent vesicle—seem to me to foreshadow in the most unmistakable way corresponding and highly characteristic events in the early development of both *Tarsius* and the Anthropoidea. We have only to suppose these ontogenetic happenings in the Lemuroids telescoped into still earlier stages as the result of developmental adaptation in order to reach the structural conditions characteristic of the early blastocysts of the other Primates, and for such adaptations to become perfected, ample time has been available, seeing that the Lemuroids and the Tarsioids were already well differentiated from each other in the Lower Eocene.

From the standpoint of embryology, I would accordingly range myself with those who, on comparative anatomical and palæontological grounds, see in the existing Lemuroids the representatives of the stock from which the higher Primates originated.

Turning now to *Tarsius* itself, our knowledge of its development may be said to be fairly complete, thanks to the untiring labours of that illustrious embryologist, the late Professor Hubrecht. In a series of papers he has provided us with richly illustrated accounts of its early development, its fœtal membranes and placentation, and he has discussed its affinities at some length. As the result of his investigations, Hubrecht came to the conclusion that *Tarsius* is no Lemur, but is more nearly related to the Anthropoidea and should be classified with them.

And there can be no doubt at all that in many features of its development *Tarsius* does appear to be more closely related to the Anthropoids than to the Lemuroids. That much is obvious from the data set forth in the table, but there are also certain differences to be noted, and our task is to try and evaluate these resemblances and differences in terms of affinity.

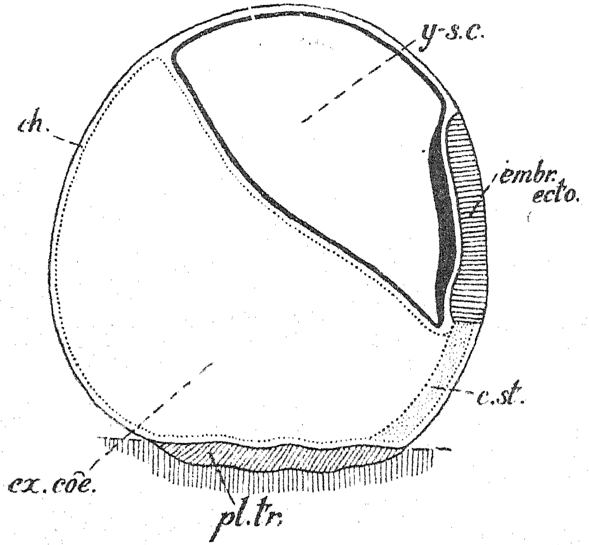
The principal developmental features in which *Tarsius* differs from the Lemuroids and agrees with the Anthropoids may be recapitulated as follows:—(1) the early attachment of the blastocyst to the uterine lining through the proliferative activity of the trophoblast; (2) the precocious formation of the extra-embryonal mesoderm and cœlom and the correlated early separation of the yolk-sac as a small reduced structure; (3) the functional replacement of the vesicular allantois by the so-called connecting or ventral stalk; and (4) the formation of a massive deciduate placenta in which the maternal blood circulates through lacunar spaces in the syncytial trophoblast.

Set down in this bald fashion, these striking resemblances between *Tarsius* and the Anthropoids would seem to settle the question of its affinities without more ado; but let us examine them a little more closely.

The attachment of the *Tarsius* blastocyst to the uterine wall, at a time when it measures only 0·3 mm. in diameter, is effected by the activity of the trophoblast over a localised patch situated immediately behind the posterior margin of the embryonal area (text-fig. 2, *pl.tr.*). All that we can say in regard to this attachment is that it represents a definite advance of an adaptive nature on the Lemuroid condition. It is the necessary preliminary to the formation of the discoidal deciduate placenta, and it is a point of interest that the attachment is effected immediately behind the embryonal area and so in proximity to the region where the allantois normally develops, although later on the definitive placenta, as the result of differential growth in the fœtal membranes, comes to lie opposite the embryo. And it may also be regarded as the first step in the evolution of the relations of the Anthropoid blastocyst to the uterus, which range from the same primitive central type of development that is seen in *Tarsius*, with in some cases an additional second attachment to the uterine wall (as in the Old- and New-World Monkeys), to the interstitial mode of development in which the blastocyst, whilst still quite minute, burrows its way, through the agency of its trophoblastic covering, into the uterine decidua and so becomes completely imbedded, its trophoblast proliferating over its entire extent (as in Man and the Anthropoid Apes). Thus the relatively simple attachment in *Tarsius* points the way to the much more highly specialised Anthropoid condition.

Then, in respect of the very early formation of the extra-embryonal mesoderm and cœlom, *Tarsius* exhibits marked adaptive specialisation as compared with the Lemuroids, and this same specialisation again reaches its acme in the Anthropoids.

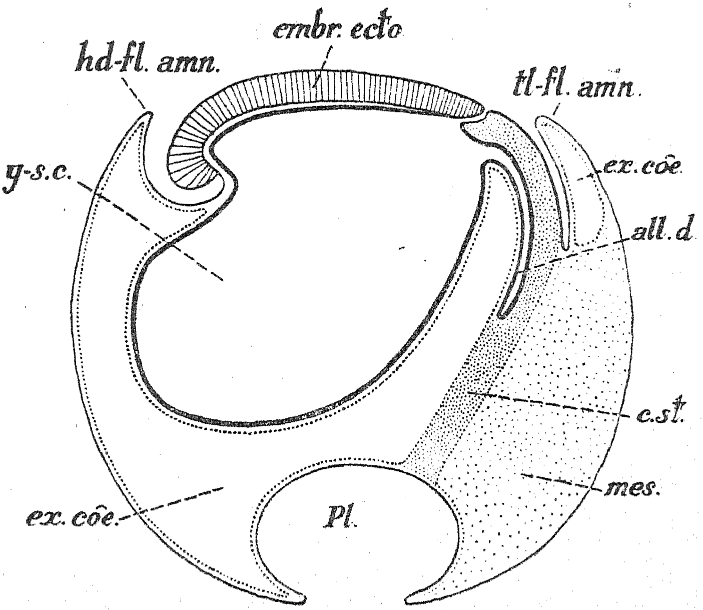
Text-figure 2.



Tarsius spectrum. Diagram (after Hubrecht) to show the structure of the early blastocyst, shortly after attachment to the uterine wall. Note the connecting stalk (*c.st.*) already present in the form of a band of mesoderm extending from the posterior end of the ectoderm of the embryonal shield (*embr.ecto.*) to the margin of the attached area of placental trophoblast (*pl.tr.*), the yolk-sac (*y-s.c.*) not yet free and the extensive extra-embryonal cœlom (*ex.cœ.*). *ch.* chorion.

Whereas in the Lemuroids, the extra-embryonal mesoderm would appear to be formed, like that of the lower Mammals, simply by the gradual peripheral extension of the embryonal into the bilaminar wall of the blastocyst, here, in *Tarsius*, it is formed precociously, long before the embryonal mesoderm has made its appearance, as a cellular mass proliferated, in the middle line, from the hinder margin of the embryonal ectoderm. Hubrecht compared it with the ventral mesoderm of the Amphibia, but, without entering into that question, what I want to suggest now is that it is none other than a precociously formed part of the primitive streak mesoderm *— a point of considerable interest, to which I refer again later. The cellular mass, so formed, extends downwards and backwards in contact with the inner surface of the attaching area of trophoblast, and in all but its proximal attached part it

Text-figure 3.



Tarsius spectrum. Diagram (after Hubrecht) to show the arrangement of the fœtal membranes, prior to the closure of the amnion. Note in particular, the yolk-sac (*y-s.c.*) now established as an independent vesicle; the connecting stalk (*c.st.*) into the proximal half of which extends the allantoic duct (*all.d.*); the placenta (*Pl.*); the thick layer of loose mesoderm (*mes.*) into which the extra-embryonal cœlom does not extend with the result that the distal portion of the connecting stalk does not become separated from the chorion; and the head- and tail-folds of the amnion (*hd-fl.amn.* and *tl-fl.amn.*). The short oblique canal perforating the embryonal area (*embr.ecto.*) is the neurenteric canal, and behind it is the primitive streak region, the mesoderm of which is directly continued into the connecting stalk (*c.st.*).

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* Prof. T. H. Bryce, in 1908, was, I find, the first to put forward the view that this mesoderm in *Tarsius* is to be considered as the equivalent of the mesoderm which is proliferated from the posterior end of the primitive streak in lower Mammals.

becomes hollowed out by the appearance in its interior of a cavity, the extra-embryonal cœlom. The entodermal yolk-sac earlier established only partially fills the space enclosed by the trophoblast, being in contact with the latter only in front (text-fig. 2, *y-s.c.*). The cœlom now rapidly expands so as to fill this space, and it also extends forwards into the front wall of the blastocyst, separating the yolk-sac entoderm from the trophoblast, with the result that the yolk-sac becomes provided with an independent wall of its own and projects into the cœlom as a small free vesicle, whilst the chorion is completed as a continuous membrane, which forms the outer wall of the embryonal formation (text-figs. 3 & 4, *y-s.c.* & *ch.*).

Thus in the mode of development of the extra-embryonal mesoderm and cœlom, in the precocious formation of the yolk-sac, and in the early differentiation of the chorion, *Tarsius* is much more specialised than the Lemuroid—nevertheless, it still retains in its ontogeny evident traces of the ancestral mode of development of these structures.

The proximal part of the extra-embryonal mesoderm in *Tarsius*, referred to above, into which the extra-embryonal cœlom does not extend, persists in the form of a solid, short, axial strand which directly connects the hinder margin of the embryonal ectoderm with the region of the chorion over which the placental trophoblastic attachment has already been effected. This strand, Hubrecht regards as the primordium of the ventral or connecting stalk, the significance of which we shall presently discuss.

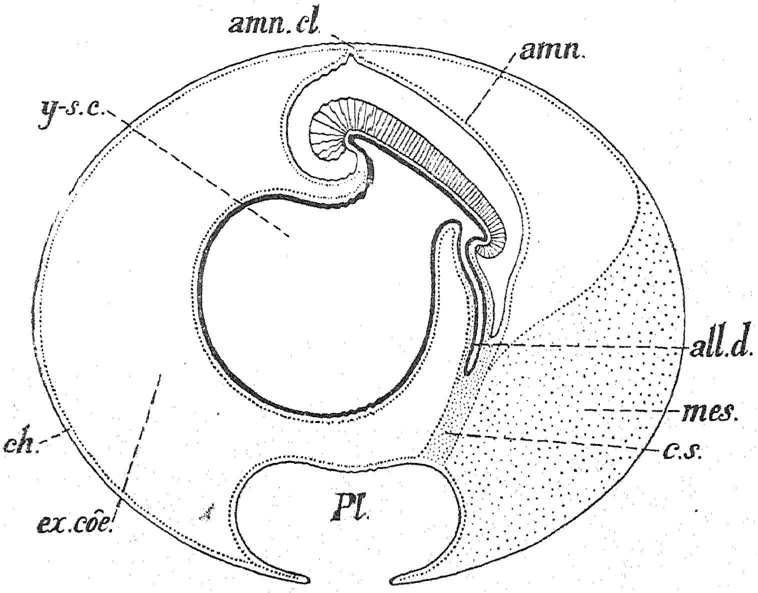
Coming now to the Anthropoids, although we know comparatively little of the details of their early development, it is quite clear from our knowledge of the structure of the early blastocyst that their early ontogeny is much more specialised than that of *Tarsius*.

The earliest-known blastocysts are already either attached to, or actually embedded in, the uterine decidua, the trophoblast has proliferated to form a syncytial network, into the meshes of which maternal blood has penetrated. Inside the trophoblastic wall there is already present a layer of extra-embryonal mesoderm (*i. e.*, the chorion is established). This layer thickens at the upper pole to enclose the embryonal primordium proper, in the form of two closed vesicles—an upper, the amnio-embryonal vesicle, and a lower, the entodermal yolk-sac. Here the embryonal ectoderm which forms the floor of the amnio-embryonal vesicle never becomes exposed on the surface as it does in *Tarsius*, and the cavity of the vesicle, the primitive amniotic cavity, persists to form the cavity of the definitive amnion, the amnion arising by the closed method and not by the closing in of folds as in *Tarsius* and the Lemuroids. The entodermal yolk-sac is most precociously differentiated as a small closed vesicle, and apparently from the first lies remote from the trophoblast. The extra-embryonal mesoderm is also most precociously developed, but as to its mode of origin we have no knowledge. It is present long before there is any trace of a connecting stalk, from which we may conclude that it does not arise like that of *Tarsius*. It is possible that it takes origin as a diffuse proliferation from the marginal ectoderm of the amnio-embryonal vesicle, as is said to be the case in *Galeopithecus* and *Tatusia*, a mode of origin which assuredly is purely secondary and adaptive.

In respect, then, of these developmental occurrences, it is evident, I think, that *Tarsius* provides the intermediate link between the primitive Lemuroids and the highly specialised Anthropoids.

We may pass on now to the consideration of the two features in the development of *Tarsius* to which Hubrecht attached most importance as guides to its affinity, viz., the occurrence of a connecting or ventral stalk and the presence of a massive placenta of the hæmochorial deciduate type. When Hubrecht first put forward his views, the existence of a connecting stalk outside *Tarsius* and the Anthropoids was unknown, and so he naturally attached great importance to it as a token of affinity, but we now know, through the researches of Newman and

Text-figure 4.



Tarsius spectrum. Diagram (after Hubrecht) to show the relations of the fœtal membranes after closure of the amnion (*amn.*). Note the temporary connection between the amnion and the chorion, marking the last point of closure (*amn.cl.*). Other reference-letters as in text-fig. 3.

Patterson, that a genuine connecting stalk, presenting a remarkable similarity to that of *Tarsius*, is also present in the Armadillo (*Tatusia novemcincta*), in which obviously it must have been evolved quite independently of that of the Primates. Nevertheless, the common occurrence of this structure in these two groups of Primates is a feature of very great interest, and the first question we have to consider is its functional and morphological significance. When fully established, it consists of a strand of mesoderm, into which there extends a tubular diverticulum (known as the allantoic duct) from the hind-gut of the embryo, and it serves to connect the posterior end of the latter directly with the chorion (text-figs. 4 & 5, *c.st.*). It is simply a mesodermal short-cut between the embryo and the enclosing chorion, and its function is to facilitate the early vascularisation of that membrane by furnishing a direct path for the umbilical (allantoic) vessels which form the essential fœtal constituent of the definitive or allantoic placenta. In the lower Mammals the chorion is vascularised as the result of the secondary union with it of the vesicular allantois, which likewise carries the umbilical vessels. Prior, however, to the establishment of the functional allantoic placenta, the nutrition and respiration of the embryo in the lower Mammals are provided for by means of a temporary omphalopleural or so-called yolk-sac placenta, involving the vitelline or yolk-sac vessels of the omphalopleure or primitive blastocyst-wall.

Now, in the Lemuroids, as we have seen, the allantois unites with the chorion relatively early, and the entire omphalopleure is rapidly resolved, through the extension of the extra-embryonal cœlom, into chorion and yolk-sac wall, with the result that a yolk-sac placenta, if it exists at all, is of quite transitory duration. In *Tarsius* and the Anthropoids, owing to the much earlier differentiation of the entodermal yolk-sac and the chorion, a yolk-sac placenta cannot be formed at all, and so as a compensation what appears to have happened in these forms is that the allantois, and more particularly the vessel-carrying allantoic mesoderm, became precociously developed in the form of a solid cord, running directly from the hinder end of the embryo to the attached area of chorion, marking the site of the future placenta.

The entodermal lining of the allantois at the same time underwent reduction, and now appears in the form of a diverticulum, usually slender and tubular, which runs from the hind-gut for a longer or shorter distance into the mesoderm of the cord.

This entire structure, then, is the connecting stalk, and what I want to insist on is that it is not something new nor is it a primitive formation (as Hubrecht maintained). It is none other than a precociously formed and adaptively specialised allantois, the object of which is to provide for the early and direct vascularisation of the chorion—or, in other words, for the nutrition and respiration of the embryo at the earliest possible moment. That this view of its significance is correct is clearly shown by its mode of development in *Tatusia*, and by its occurrence in the Marmoset (*Hapale*) in a condition which can best be described as semi-vesicular. In *Tarsius*, its primordium is constituted at first, according to Hubrecht, simply by the unsplit proximal portion of the axial mesoderm proliferated from the hinder margin of the embryonal ectoderm; if we are justified in regarding this mesoderm as precociously formed primitive streak mesoderm, then the connecting stalk of *Tarsius* can also be brought into line with what we know of the development of the allantois in lower Mammals. The predisposing factor in the evolution of the connecting stalk in *Tatusia* and *Tarsius* is doubtless to be sought in the placental attachment which is early established by the trophoblast situated just behind the embryonal area and in immediate proximity to the normal seat of origin of the allantois.

As to the development of the connecting stalk in the Anthropoids, we have no certain knowledge. It seems probable, however, that it does not arise in the same way as in *Tarsius*, but that, to begin with, it is simply formed by the persistent hinder portion of the layer of extra-embryonal mesoderm which in the early blastocyst lies between the amnio-embryonal vesicle and the trophoblast. Through the extension of the cœlom, this layer would seem to become split into chorionic mesoderm on the outside and amniotic mesoderm on the inside, except posteriorly,

Text-figure 5.

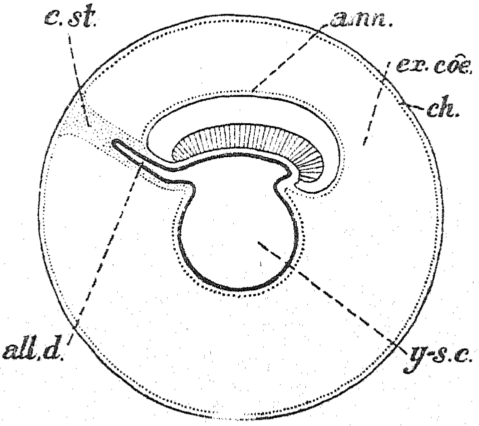


Diagram to show the structure of the early blastocyst in the Anthropoidea. Note the embryonal ectoderm (cross-lined) forming the floor of the amnio-embryonal vesicle (*amn.* amnion), and the underlying yolk-sac vesicle (*y-s.c.*); the connecting stalk (*c.st.*) with the allantoic duct (*all.d.*); and the extensive extra-embryonal cœlom (*ex.cœ.*) bounded by the chorion (*ch.*).

where it apparently persists as a solid strand, connecting the embryonal formation directly with the chorion (text-fig. 5, *c.st.*). Even if this strand is reinforced later by mesoderm of primitive streak origin, it is clear, if the connecting stalk arises in the way outlined, that it is more cænogenetically modified than is that of *Tarsius*, the latter providing the link between the Lemuroids and the Anthropoids.

In both *Tarsius* and the Anthropoids, the connecting stalk later on becomes enclosed with the yolk-stalk in a tubular prolongation of the margin of the umbilical opening, which carries the amnion with it. The cord-like structure so formed is the umbilical cord, which connects the embryo with the placenta. In examining the fœtal *Tarsius* which Dr. de Lange so kindly sent me, I noticed that the cord is related to the placenta somewhat differently to that of the Anthropoids. Whereas in the latter, the cord takes the form of an elongated, more or less twisted, rope-like structure which runs as a free cord to become connected with the chorion covering the free surface of the placenta, usually near its centre, in *Tarsius* the cord is quite short, and instead of passing directly to the placenta, it joins the chorion soon after it becomes clear of the body of the fœtus and runs down in that to join the distal margin of the placenta (text-fig. 1). This difference confirms the conclusion we reached above that the development of the cord does not follow identical lines in the two groups.

Lastly, let us see what conclusions as to the affinities of *Tarsius* may be drawn from the study of the placenta itself. The development and structure of this remarkable organ were described by Hubrecht in a lengthy paper published in 1899, but in that paper Hubrecht was more concerned with demonstrating the occurrence of a supposed blood-forming or hæmopoietic process in the placenta than with the description of the structure of the ripe organ itself, and his figures fail to convey an adequate idea of its characteristic structural features. That defect I have attempted to remedy by the provision of the microphotographs of sections of the nearly full-term placenta shown in fig. 1, and herewith reproduced as figs. 2, 3, and 4, Pl. I.

These figures supplement Hubrecht's account of the placenta very materially, and illustrate quite adequately, I think, the more important features in its structure. From these figures, anyone who is familiar with the sectional appearance of the human placenta, will recognise at once that he is dealing with a placenta of the Anthropoid type. Hubrecht, with reference to his own fig. 66, remarks "eine entfernte Aehnlichkeit mit der menschlichen Placenta, wie sie Sedgwick Minot abbildet, ist nicht zu verkennen," and that is certainly the conclusion that any competent embryologist would come to from an inspection of my fig. 4. The general resemblance is indeed extraordinarily striking, but, whilst that is so, it must be emphasized that in its detailed structure, the *Tarsius* placenta shows peculiarities of its own which clearly mark it off from the Anthropoid placenta. Although it foreshadows the latter in the most unmistakeable fashion, it has failed to attain the same level of structural and functional differentiation.

The mature placenta of *Tarsius*, viewed as a whole (*cf.* fig. 1, Pl. I., where it is seen in section) appears as a massive knob-shaped or rather cone-shaped structure, measuring, in my specimen, 10×11 mm. in diameter, which projects freely into the uterine lumen and is attached to the very thin uterine wall in the apical region of the uterine horn by a very short stalk through which the maternal vessels pass. Its distal, slightly concave surface is clothed by the chorion which marginally is, on the one hand, reflected down to invest the remainder of the free surface, right down to the stalk, and on the other, is continued on as non-placental chorion, a very thin non-vascular membrane, with whose inner surface the amnion lies in close apposition. In its cone-shaped form and freely projecting character, it contrasts with the sessile, cake-like, discoidal placenta characteristic of the Anthropoids. These features are dependent on the fact that the placenta develops in relation to a localised knob-like thickening of the subepithelial tissue of the uterus, the decidual swelling or trophospongia. To this, attachment is effected in the first instance, and it later on projects and serves as an axis round which the cone-shaped placenta develops. In the process it undergoes progressive degeneration, and only a remnant of it is preserved in the stalk-region of the completed placenta. Its presence in the developing placenta no doubt conditions the appearance of the extensive blood-extravasation which is such a marked feature in the ripe organ (fig. 2). No such conspicuous, localised, decidual swelling has so far been described in the placental development of any Anthropoid.

The *Tarsius* placenta agrees with that of the Anthropoids in that it is deciduate and of the hæmochorial type, *i.e.*, the functional placenta consists, except for the maternal blood present in it, exclusively of fœtal tissue and the maternal blood circulates through lacunar spaces bounded solely by the fœtal trophoblast. This same type of placenta, however, occurs also in such diverse orders as the Rodentia, Cheiroptera, Insectivora, and Xenarthra, so that this similarity does not carry us very far. A more important agreement, from our present point of view, lies in the fact that the functional placenta comes to be established as the result of the outgrowth from the mesoderm of the chorion of more or less massive sprouts which grow into the syncytial layer formed by the trophoblast and which branch abundantly to form characteristic dendritic villi, in which the fœtal vessels are situated. At the same time, the trophoblast provides, apparently in a somewhat different fashion in the two groups, an enclosing layer round each villus (including all its branches), whilst its blood-filled lacunæ extend so as to form a system of intervillous blood-spaces. But there is an important difference in the villi in the two groups, for, whereas in the Anthropoid placenta the villi are strongly marked and individualised structures which project freely into what is practically a continuous blood-sinus formed by the confluence of the intervillous spaces, in *Tarsius* they are less prominent structures and except at their origin from the chorion cannot be said to be individualised at all, since their enclosing layers of syncytial trophoblast are not individually distinct but are connected with each other by anastomoses, the trophoblast persisting in the form of a syncytial network, in the walls of which the mesodermal villi are enclosed (Pl. I. figs. 3 & 4).

Furthermore, the intervillous spaces, except round the periphery of the placenta, immediately below the chorion, where they have coalesced to form definite blood-sinuses of some size (Pl. I. figs. 2 & 3), take the form elsewhere of narrow and tortuous channels, which, indeed, in the deeper parts of the organ are frequently incompletely hollowed out, many of them being more or less blocked by a light-staining reticular material (Pl. I. fig. 4), no doubt derived from the breaking down of the trophoblast during the formation of its lacunæ, but which has not been completely removed, owing perhaps to the slowness of the circulation in the central region of the organ. Compared with the Anthropoid placenta, that of *Tarsius* strikes one as being on a much lower plane of functional efficiency.

Hubrecht in one of his more recent papers (1908) has himself emphasised the above-described difference in the relations of the villi. He writes:—"The freedom with which they float about in the maternal blood is another characteristic of Man and the Monkeys. In *Tarsius* and in the Hedgehog their arrangement is more that of a suspension in a very delicate and at the same time most intricate trellis-work formed by the trophoblast cells that have become spun out into this. When the connecting trabeculæ of this trellis-work are suppressed, as we see it in the higher Primates, the surface available for osmotic interchange is naturally increased and the free movements of the villi may also be considered as an advantageous circumstance." Leaving aside consideration of certain other differences in detail in the placentation of the two groups, *e. g.* in the early development, in the constitution of the investing trophoblastic layer of the villi, and in the occurrence of placental blood-extravasations, we may deduce from the above quotation that Hubrecht regarded the difference between the *Tarsius* and Anthropoid placenta as one of degree only and that he looked upon the former as a much less perfect organ functionally than the latter.

With these deductions, I am in agreement with the reservation that I hold the degree of difference to be such as to justify us in definitely excluding *Tarsius* from the Anthropoid group. In its placentation, *Tarsius* is clearly on the line which leads to the Anthropoids, but it has failed to attain their status, and in this respect, as in so many others, is a true "Halbaffe," intermediate between the Lemuroids and the Monkeys, but approaching much more closely to the latter than to the former.

The conclusions we have arrived at from the consideration of the data of development may be summarised as follows:—(1) The Lemuroids represent the basal stock from which the higher Primates evolved. They have retained in their development many primitive Mammalian features, including a primitive form of diffuse non-deciduate placenta. Developmentally they are free from marked specialisation, and they present us with a developmental ground-plan of such a generalised type as to be easily susceptible of such adaptive modifications as have occurred in the higher types in the course of evolution. (2) The Tarsioids, early separating from the primitive Lemuroid stock, were more progressive. They show in their development the beginnings of those adaptive changes which reach their culmination in the Anthropoids, and by acquiring an early attachment to the uterine wall they developed a localised deciduate placenta of the hæmochorial type; but for some reason, perhaps owing to a too active participation on the part of the maternal decidua, they failed to exhaust its possibilities and to evolve an organ of the highest possible efficiency. In many features of their development, they are transitional between the Lemuroids and the Anthropoids, but they are plainly on the Anthropoid line, and from them the Anthropoids undoubtedly took their origin. (3) Starting from the Tarsioid stock, already provided with the beginnings at least of a hæmochorial placenta, the Anthropoids went on to make the most of their inheritance, and evolved a highly efficient type of nutritive organ in which the individualised villi are directly bathed by the maternal blood—an efficiency which is reflected in the advanced grade of organisation exhibited by the new-born young. In them and more particularly in the highest forms, the Anthropoid Apes and Man, developmental adaption has reached its acme, as witness the complete implantation of the early blastocyst and the correlated development of a complete decidual capsule; and here I may be permitted to add, of the close genetic affinity of Man and the higher Apes there can be no question on embryological grounds.

Finally, as regards the systematic position of *Tarsius*, Hubrecht's contention that it must be removed from the Lemurs I fully accept, but I am unable to agree that its true position is with the Anthropoids. The remarkable annectant characters which *Tarsius* exhibits justify us in placing it, along with its extinct allies, in a subdivision of its own, and I am, therefore, in agreement with those who, like Gadow and Elliot Smith, have advocated, on quite other grounds, the division of the Primates into three great radiations—call them what you may,—viz. a basal or Lemuroid group, a Tarsioid group, and an Anthropoid group. This tripartite arrangement seems to me most in accord with the embryological data and best expresses the phylogenetic importance of this extraordinary creature, outside Man—perhaps the most interesting of all the Monodelphian Mammals.

I desire to express my thanks to my Laboratory Assistant, Mr. F. J. Pittock, for the skill and care he has expended on the preparation of the Plate.

Comparative Tablė, Development of Primates.

(1) LEMUROIDS.	(2) *Tarsius.*	(3) ANTHROPOIDS.
1. Development central.	as in (1).	as in (1) or interstitial.
2. No attachment to uterine wall. Trophoblast relatively inactive.	Attachment very early effected by localised thickening of trophoblast.	Trophoblastic activity more marked than in (2). A single or double attachment or interstitial imbedding very early effected.
3. Amnion formed by fold-formation with proamnion.	as in (1), but without proamnion.	Closed amnion-formation, the primitive amniotic cavity persisting.
4. Allantois free and vesicular; unites fairly early with chorion.	Allantois never free and vesicular, transformed into "connecting stalk."	as in (2), but connecting stalk semivesicular in *Hapale.*
5. Yolk-sac formed in normal fashion, but is early separated and soon becomes reduced.	Yolk-sac precociously formed and reduced from the first, never completely filling space enclosed by the trophoblast.	as in (2), but even more precocious and more reduced.
6. Formation of extra-embryonal mesoderm and cœlom normal, but they extend relatively early through entire omphalopleure.	Extra-embryonal mesoderm and cœlom precociously formed.	as in (2) but distinctly more specialised.
7. Chorion vascularised throughout by allantois.	Chorion extremely thin and non-vascular, except over placental area, which is vascularised through connecting stalk.	Chorion vascularised throughout by way of connecting stalk.
8. Yolk-sac placenta, if present, transitory.	No yolk-sac placenta.	as in (2).
9. Placenta diffuse, non-deciduate, epithelio-chorial in type.	Placenta conical, deciduate, hæmochorial in type, but villi not individualised and clothed by syncytio-trophoblast only.	Placenta single or double discoidal and hæmochorial, villi distinct and projecting into maternal blood-sinus. Trophoblast of villi distinguishable into syncytio- and cyto-trophoblast.

EXPLANATION OF PLATE I.

Fig. 1. Photograph (× 1·5) of fœtus of *Tarsius spectrum* (measuring 2·9 cm. in G. L.), after removal from the uterine horn and with the cone-shaped placenta attached. The short umbilical cord is seen to join the chorion shortly after becoming clear of the body of the fœtus and to run down in that membrane to join the placenta marginally. The placenta has been divided by a vertical cut, the cut-surface showing (*cf.* fig. 2 and explanation thereof).

[Hubrecht Coll., *Tarsius* 76. Coll. Dr. Fock, Muntok Bankaleg, 17th March, 1893.]

Fig. 2. Photomicrograph (× 6) of vertical section of the entire placenta, well to one side of the area of attachment to the uterine wall. Note the investing chorion with the main stems of the villi arising from it (best seen on upper side of the section), the peripheral blood-sinuses, and the large blood-extravasation centrally.

Fig. 3. Photomicrograph (× 35) of a small portion of the superficial region of the placenta (including the large villus visible in the upper left-hand sector of fig. 2). Note the chorion forming the boundary of the section on the upper side, the peripheral blood-sinus, and a large and a small villus-stem arising from the chorion, the former showing well the characteristic method of branching.

Fig. 4. Photomicrograph (× 80) of a portion of the placenta, situated a little deeper than the base of fig. 3, to show the villi under higher magnification. The villi are mainly cut transversely, and in the region photographed are, on the whole, of greater than average diameter. Each villus consists of a core of chorionic mesenchyme carrying the umbilical vessels and invested by a more deeply stained sheath composed of a thin nucleated layer of syncytial trophoblast. An underlying layer of cyto-trophoblast such as is found in the villi of Anthropoids is at no time present in *Tarsius*. Adjoining villi are connected by bridges of syncytio-trophoblast, the latter thus forming an irregular network. Between the villi are the intervillous spaces, many of them being more or less completely occupied by the reticular light-staining material referred to in the text (p. 488).

Prof. F. Wood-Jones, D.Sc., M.B., F.Z.S. :—Although the general anatomy of *Tarsius* may be said to be fairly well known, there is still great need for complete accounts of dissections of special systems and for the general examination of a larger number of specimens. Apart from the gaps in our knowledge of several important details, there is as yet no basis for forming an estimate of the range of individual variation.

As a result of comparing published accounts of the anatomy of *Tarsius* and from dissecting an adult female specimen, one can only conclude that either the range of individual variation is considerable or the interpretations of different investigators show a rather unusual lack of agreement. External characters have been studied in two specimens, both adult females, and the details of bodily structure in one of them; in addition, I have had X-ray photographs of various portions of both specimens. [For my material I am indebted to Profs. G. Elliot Smith and J. P. Hill, and for the X-ray plates to Dr. Stanley Melville.] For the purpose of this discussion it is impossible to furnish more than a summary of the anatomical details, and I have thought it best to mention only the outstanding features which are likely to throw light on the affinities of *Tarsius*, dealing especially with those points which link it to, or separate it from, the typical members of the Lemuroidea and Anthropoidea respectively.

It cannot be doubted, from an examination of its entire anatomy, that *Tarsius* is a remarkably primitive mammal which has early acquired an over-specialisation in vision and in powers of frog-like arboreal leaping. In these two features it roughly resembles *Galago*, and it may be doubted if, had this likeness not been so apparently exact, zoologists would have classed *Tarsius* in the Lemuroidea with so much confidence. One primitive feature retained by the specimen dissected is the presence in the carpus of an element which I can only homologise as a second os centrale. This small bone has not previously been described, and its detection without the use of X-rays would be rather a matter of chance. The true os centrale (os accessorium, *Burmeister*) articulates with carpale I., II., and III., as well as with the scaphoid and semilunar (thus differing from the condition as described and figured by Burmeister).

The second os centrale exists on the radial side of the carpus in the gap between carpale I. and the scaphoid; it does not actually articulate with any bone, being held in place by fibrous tissue. It is not situated in tendon, but is enveloped in the capsule of the carpal articulation. Should this small bone prove to be a constant element in the carpus of *Tarsius*, it would furnish very interesting evidence to which it is hoped attention will be given by other observers having command of material. *Tarsius* differs from all members of the Lemuroidea in certain of its external characters:—(I.) In having the nostril completely ringed by the meeting of the lateral and medial nasal processes. In this encircling of the nares it resembles all members, and surpasses some, of the Anthropoidea. (II.) In having the upper lip simple in the mid-line. There is no lemurine incisura between maxillary processes, but a truly Simian philtrum composed of medial nasal processes. (III.) The hair-tracts resemble those of the highest of the Anthropoidea far more nearly than they do those of the Lemuroidea, or even the lower Anthropoidea. (IV.) The digital formula differs from that typical of the Lemurs, the middle line digit being the longest. (V.) The metacarpal formula shows the same primitive and non-lemurine features. (VI.) The external genitalia, especially those of the female, are formed upon a plan altogether unlike that seen in the Lemurs and resembling that typical of the highest Anthropoidea.

In its internal anatomy *Tarsius* differs from all members of the Lemuroidea in (VII.) its dental characters; (VIII.) in the formation of the auditory bulla; (IX.) in the form and fate of the tympanic bone, and in the inception of an external auditory meatus. Combined with these last two characters is (X.) the non-lemurine cranial course of the internal carotid artery. In the formation of the orbit two characters, typical of the Anthropoidea and differing widely from anything seen in the Lemurs, are conspicuous: (XI.) with the inner wall of the orbit the os planum of the ethmoid enters, and (XII.) the orbit is furnished with a posterior wall in the formation of which the alisphenoid takes part. (XIII.) The hyoid, with its relatively short "lesser" cornua, differs from the typical hyoid as seen in the Lemurs, and resembles that of the monkeys and apes (Burmeister's figure and account of the hyoid does not accord with the condition present in my specimen). (XIV.) The trachea is not formed upon the peculiar lemurine fashion, for the rings are incomplete behind, as they are in the Anthropoidea. (XV.) The two halves of the mandible are synostosed in the middle line. (XVI.) The ventral pelvic symphysis is shallow, and is limited to the pubis. In the gastro-intestinal tract the very widest differences exist between *Tarsius* and any members of the Lemuroidea, and for the purpose of summary we will only note (XVII.) the simplicity of the gut pattern of *Tarsius*, and the absence of any coiling which is so characteristic of the Lemurs. In many features the myology of *Tarsius* differs from that of the Lemurs and resembles that of the Monkeys and Apes; as an example, (XVIII.) the very human disposition of the digastric muscle may be instanced. In the vascular system (XIX.) the arrangement of the vessels on the arch of the aorta provides a striking contrast to the condition seen in the Lemurs.

In summing up the entire anatomy of the Lemurs and of the Monkeys and Apes it is impossible to avoid appreciating "the differences in structure that indicate the wide separation of the Lemuroidea and the Anthropoidea" (Elliot Smith, 'Nature,' May 2, 1907, p. 7). Judged by such standards as are commonly employed in mammalian classification, such basal features as those comprised in the structure of the nose and lips, in the tympanic and orbital regions of the skull, and in the genitalia appear to justify the separation of *Tarsius* from the Lemuroidea, and warrant its inclusion in the Anthropoidea. But in several very striking details *Tarsius* differs from all members of the Anthropoidea except the very highest. In many characters *Tarsius* resembles *Homo* and differs from the Monkeys, in some it resembles *Homo* and certain of the Anthropoid Apes. These features are only to be termed primitive mammalian characters, and as a result of summarising the anatomy of the Anthropoidea it appears to me to be legitimate to conclude that *Tarsius* and *Homo* retain a remarkable series of primitive mammalian characters, some of which are retained in part in the Anthropoid Apes, but which are departed from increasingly widely as the zoological scale of the Anthropoidea is descended. (I.) *Tarsius* differs from all Anthropoidea except Man and the Orang in the arrangement of the elements in the basis cranii; here it resembles all primitive mammals. (II.) It differs from all Anthropoidea, with the same two exceptions, in the normal retention of the alisphenoid-parietal pterion. (III.) In the digital and metacarpal formulas it shows a primitive (and human) character in avoiding the relative reduction of the 2nd digit of the manus typical of the remaining members of the Anthropoidea. (IV.) In the external genitalia the affinities of *Tarsius* are far nearer to the highest members of the series than they are to the lowest. (v.) In the absence of a penile ossicle or penile cartilage, the likeness is with *Homo* alone. (vi.) In the arrangement of the aortic trunks *Tarsius* differs from all monkeys, and finds an absolute parallel only in Man normally and certain Anthropoids occasionally. Various points in myology are of interest as showing retention of muscles in *Tarsius* and *Homo* in a primitive condition not preserved in other members of the Anthropoidea. (vii.) *Tarsius* retains, like *Homo*, a well-developed palmaris brevis. (viii.) The flexor accessorius is confined to *Tarsius* and Man alone among the Primates. (ix.) The supinator brevis is pierced by the posterior interosseus nerve exactly as it is in Man, and the condition differs widely from that which is occasionally present in the Chimpanzee, and which is otherwise the most human manifestation of this muscle within the limits of the Anthropoidea. (x.) The palmaris longus and plantaris are both well developed. (xi.) The levator anguli scapulæ is in its human condition. (xii.) The flexor pollicis longus, though judging from published accounts displaying a variability in different specimens, approaches the human form and differs from the Simian in a very remarkable manner.

In conclusion, *Tarsius* appears from a summation of its anatomical characters to belong to the Anthropoidea, of which group it constitutes one of the most primitive members. In the retention of primitive features of bodily architecture it finds its parallel in *Homo*; and it differs from the rest of the Anthropoidea in which Simian specialisations have effected definite alterations.

Tarsius appears to be a very primitive member of the Anthropoidea in which early specialisation of vision and arboreal leaping activities absorbed the phylogenetic development of the species. *Homo* appears also as an extremely primitive form in which cerebral advances, and lack of unequal physical specialisation, save that of bipedal progression, is the phylogenetic keynote. The Anthropoid Apes have departed more from the primitive mammalian type in definite "Simian" specialisations—which specialisations become increasingly conspicuous in the "lower" members of the Order.

R. I. Pocock, Esq., F.R.S., F.Z.S.:—In the 'Proceedings' of this Society, Aug. 1918, I pointed out that *Tarsius* differs from all the Lemurs and resembles the higher Primates in the structure of the nose and muzzle and in the mobility of the lips; and that the external genitalia of the female in the concealment of the small clitoris and the orifices of the urethra and vagina by a pair of labia are unlike those of the Lemurs, especially of the Oriental and African forms (Lorisiformes), and recall rather those of the Old-World Pithecoid Primates.

These differences between *Tarsius* and the Lemurs, added to those previously established in connection with the skull and teeth, the placenta and the digital formula of the hand, outweighed, in my opinion, the likeness between *Tarsius* and the Lemurs, and enforced the removal of the former from the latter and its association with the Monkeys, Apes, and Man in a group of the Primates for which the term Haplorhini was proposed, the true Lemurs, the Lorises, and *Chiromys* being graded in contradistinction as Strepsirhini. The Haplorhini were divided into two suborders, the Tarsioidea for *Tarsius* and the Pithecoidea for the Platyrhini (American Monkeys) and the Catarhini (Old-World Monkeys, Apes, and Man).

This classification appeared, and still appears, to me to express the known facts more accurately than its predecessors, the nearest to it being that of Gadow who in 1898 definitely dissociated *Tarsius* from the Lemurs, dividing the Primates into the three suborders Lemures, Tarsii, and Simiæ. Possibly he would have anticipated my systematic arrangement had he been acquainted with the structures connected with the muzzle and vulva in *Tarsius* and other Primates and attached to them the importance that I do.

J. T. CUNNINGHAM, M.A., F.Z.S.:—In the development of Mammals generally segmentation of the ovum produces a small internal mass of cells covered by a single layer of external cells. Accumulation of watery liquid between these two parts produces the blastocyst, a vesicle of epiblast cells with the inner cell-mass adhering to the inner surface of the vesicle at one small area. The wall of the vesicle is the trophoblast, which corresponds to the epiblast layer of the serous membrane or false amnion of birds and reptiles. The next step in the mammal is the differentiation of the hypoblast from the lower surface of the inner cell-mass: this hypoblast grows round the inner surface of the blastodermic vesicle, and so forms the inner lining of the yolk-sac. The amnion is formed either by coalescence of external folds above the inner cell-mass or as a closed cavity within the latter. The mesoderm is formed next by differentiation between the epiblast and hypoblast within the inner cell-mass, which may be now called the embryo. The mesoblast extends between trophoblast and hypoblast, and between trophoblast and amnion, splitting as it goes to form a cavity called the extra-embryonic cœlom. By folding in of the sides of the embryo the connection of yolk-sac and embryonic gut is narrowed, and from the hinder end of the gut grows out the allantois as a hollow sac into the extra-embryonic cœlom.

We have thus a membrane called the chorion, consisting of an external layer of epiblast and an internal layer of mesoblast, entirely enclosing the embryo with its three membranes, the amnion surrounding it dorsally, and the yolk-sac and allantois extending from the gut ventrally. These two sacs occupy varying proportions of the inner surface of the chorion in different mammals. In Ungulates the cavity of the allantois is very large and its outer wall is in contact with the inner surface of the chorion over very nearly its whole extent, the yolk-sac becoming very small. The chorion grows out into villi over its whole surface, and these villi penetrate into pits or crypts of the inner surface of the uterus, without becoming united with uterine tissue. The mesoblast of the allantois with its blood-vessels grows into these villi and thus is formed the diffused placenta.

In Man the amnion appears to be formed as a closed cavity, and the hypoblast develops as described above, but instead of extending round the inner surface of the chorionic vesicle it forms a small closed sac, and mesoblast develops on the inner surface of the chorion and the outer surface of the yolk-sac with a large cavity between, which is the extra-embryonic cœlom. There is at first no mesoblast within the embryo, but it extends outside the amnion and attaches the embryo to the mesoblastic lining of the chorion. As the embryo develops, this connection lengthens somewhat and becomes first posterior then ventral. This connecting mesoblast is the umbilical cord, and represents a solid allantois, into which a very rudimentary cavity extends from the hinder end of the gut. The mesoblast at the outer end of the stalk forms villi over a disc-shaped area of the chorion and so forms a discoid placenta.

With regard to these peculiarities of development, the ordinary Lemurs agree with the Ungulata and *Tarsius* agrees with Man. It may be said, therefore, that there is as much difference between the development of *Tarsius* and that of a Lemur as there is between that of Man and that of an Ungulate. Moreover, in Man the trophoblast destroys and absorbs the uterine mucous membrane and the allantoic villi extend into embryonic trophoblast-tissue. In this respect also *Tarsius* agrees with Man and differs from Lemurs. To suppose that the mode of development of *Tarsius* and Man has been independently evolved without any close relationship between the two seems to me unreasonable.

The development of *Tarsius* is more similar to that of Man in some respects than that of Monkeys and Apes. In many Monkeys there are two placentas, a dorsal and a ventral; in Man only one, which is dorsal. In *Hylobates* and *Simia* there is only one placenta, but it is ventral. In *Tarsius* the placenta is single and dorsal. The Apes, however, are nearer to Man in having the chorion entirely imbedded in uterine tissue, which is not the case in Monkeys or *Tarsius*.

Dr. P. CHALMERS MITCHELL, F.R.S.:—Characters have to be judged as well as counted, if it be intended to use them for estimating the relative degree of affinity between animal types. No anatomist doubts but that Man retains many primitive characters; Anthropoid Apes, Old-World Monkeys, American Monkeys, *Tarsius*, and Lemurs also retain many primitive characters. It is reasonable to assume that the common ancestors of all these animals possessed all the primitive characters retained by any of them. And so it is not surprising to find any primitive character in any descendant of a common stock, but there is no reason to suppose that, because any two have retained the same primitive character, they should for that reason be judged more nearly related than either may be with some other descendant of the common stock. Primitive characters may be useful for the description or definition of a group—they have no value for assigning degrees of affinity. These considerations ought to be commonplaces in zoological argument, but they are often forgotten, and I think they have been entirely forgotten by Professor Wood-Jones in the imposing list of common characters that he has drawn up for Man and *Tarsius*. Fortunately they have been remembered by Mr. Pocock, and Professors Hill and Elliot Smith, and the considerations they adduce have disposed of Professor Wood-Jones's argument that *Tarsius* has a special relation to the ancestry of Man. It may not be a Lemur, but it is no nearer to Man than to other Primates.

Professor Wood-Jones, to whom we are indebted for originating the interesting discussion, was more reticent to-night than in his addresses to more popular audiences. He attacked Darwinian evolutionists, and Huxley in particular, on the supposition that they believed genealogical trees to be linear, that a higher group took origin from the highest members of a lower group. It was a strange misreading of familiar evidence. Were he to consult Huxley's Essay on "Man's Place in Nature," or any general statement of the case for Evolution, as, for instance, the Article under that heading in the 'Encyclopedia Britannica,' he would see that he was attacking a bogey that does not exist. Writer after writer, with increasing insistence in recent years, has dwelt on the obvious fact that existing groups are at most in the relation of collateral descendants of a common ancestor, and the tendency has been to place the common ancestor ever lower and lower on the tree of life.

Prof. MacBride, F.R.S.:—In summing up the discussion the Chairman said that there was one point on which all the speakers were agreed, viz., that *Tarsius* was much more nearly allied to the higher Primates than it was to the Lemurs. But that was a point which under any circumstances few would have disputed, especially since Prof. Hubrecht's researches on the placentation of this form which had been so ably summarised for us by Prof. Hill. The whole interest of the question lay in Prof. Wood-Jones's attempt to prove that *Tarsius* and Man agreed in retaining important primitive characters which the other Monkeys had lost—and in the obvious inference from this position, from which Prof. Wood-Jones had rather shrunk during the discussion, but to which he had liberally committed himself in recent books published by him. This inference was briefly that the human stock had separated from the stock of Primates at the *Tarsius* level and that all resemblances between the two stocks were due to convergent evolution.

In Prof. MacBride's opinion the points of similarity between *Tarsius* and Man adduced by Prof. Wood-Jones were superficial peculiarities, and the assertion that these structural characteristics were absent from Monkeys seemed to rest largely on our imperfect knowledge of the anatomy of Primates, as the admission of Prof. Wood-Jones that some of them appeared as "exceptions" in the Chimpanzee and the Gorilla amply proved. Prof. Elliot Smith had rightly emphasised the deep and fundamental resemblances between the Higher Apes and Man, and his exposition would leave no doubt in the minds of most of us that the older view that Man was sprung from a Simian stock was true.

The great interest in the question of Man's origin was to discover the cause of his evolution, for we might rest assured that Man did not evolve in response to an innate tendency lodged in a Monkey's constitution, but in response to needs created by a change in the environment. The Apes were arboreal animals; and Man was, anatomically, a Ground-Ape. When towards the end of the warm Tertiary period, the forests began to shrink and to be replaced by steppes swarming with swift-footed grazing animals, the restriction of food on the trees and its obvious abundance in the plains led to the most enterprising Apes venturing on to the ground and assembling in troops to run down their prey, and thus a beginning in the evolution of Palæolithic Man the primitive hunter was made.

The race of squirrels, essentially tree-loving animals, had, in like manner, spread into steppes and prairies, and given rise to short-tailed short-legged forms like the Prairie-Dog and the Marmot, which were essentially Ground-Squirrels.

If these considerations were justified, it followed that the phrase "Arboreal Man" was a contradiction in terms.

November 4th, 1919.

A. Smith Woodward, Esq., LL.D., F.R.S., Vice-President, in the Chair.

Mr. F. Martin Duncan, F.R.M.S., F.Z.S., exhibited a series of photographs showing the actinic quality of the light from a living *Pyrophorus* Beetle, and described the method he had employed to obtain his records. He stated that the results obtained appeared to show that photo-spectroscopically the greatest intensity of light action was in the yellow-green region. Unfortunately the single specimen at his disposal was already in a somewhat exhausted condition on coming into his hands, so that he was unable to investigate the matter as thoroughly as he would have desired.

Mr. E. HERON-ALLEN, F.R.S., F.Z.S., exhibited a series of Skiagraphs of the Foraminiferan genus *Verneuilina* from examples grown in a hypertonic tank, and described some of the further results that he and Mr. A. Earland, F.R.M.S., had obtained in the course of their investigations, drawing particular attention to the remarkable modifications produced in the morphology of the "test" of the specimens exhibited.

November 18th, 1919.

Prof. E. W. MACBRIDE, F.R.S., F.Z.S., Vice-President, in the Chair.

The SECRETARY read the following Report on the Additions made to the Society's Menagerie during the month of October 1919:—

The registered additions to the Society's Menagerie during the month of October were 138 in number. Of these 64 were acquired by presentation, 55 were deposited, 15 were purchased, and 4 were born in the Menagerie.

The following may be specially mentioned:—

2 Musk-Oxen (*Ovibos moschatus*), new to the Collection, from Greenland, purchased on October 9th.

2 Lions (*Felis leo*), ♂ ♀, from Africa; 3 Leopards (*Felis pardus*), ♂, 1 Nylghaie (*Boselaphus tragocamelus*), ♀, from India: presented by The Rajah of Payagpur on October 4th.

1 Leopard (*Felis pardus*), 2 Striped Hyænas (*Hyæna hyæna*), from India, presented by The Rani of Bansi Basti on October 4th.

1 Blackbuck (*Antilope cervicapra*), ♀, 1 Sambur (*Rusa unicolor*), ♀, from India, presented by W. B. Cotton, Esq., I.C.S., on October 4th.

1 Blackbuck (*Antilope cervicapra*), ♂, from India, presented by Dr. Gulzeri Lal on October 4th.

A collection of Birds from New Guinea and the Malay Archipelago, including four Lesser Birds of Paradise (*Paradisea minor*), and containing several species new to the Collection, deposited on October 27th.

Sir EDMUND GILES LODER, Bt., F.Z.S., exhibited and made remarks on a series of skulls of the Beaver, showing a separate ossicle between the parietals.

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- PISCES: On certain features of the otic region of the chondrocranium of *Lepidosteus*, 245; On the occurrence of Denticles on the Snout of *Xiphias gladius*, 321; On new fishes from the West Coast of Lake Tanganyika, 399.
- REPTILIA: On a new species of Zeuglodont and of Leathery Turtle, 309; On a new Snake, and Batrachia from Madagascar, 349; On the number of dorsal Scale-rows in British Snakes, 357.
- INSECTA: On the species of *Balaninus* occurring in Borneo, 365.
- MOLLUSCA: The Radula of the Mitridæ, 405.
- ECHINODERMATA: Note on the Righting Reaction in *Asterina gibbosa* Penn., 423.
- ACTINIÆ: On the development of the Mesenteries in *Urticina crassicornis*, 453; On the ciliation of the Leptomedusan *Melicertidium octocostatum* (Sars), 459.

Tanais nierstraszi, sp. n., 332.

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No. 187.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

February 4th, 1919.

Dr. S. F. Harmer, F.R.S., Vice-President,
in the Chair.

The Secretary read a report on the Additions to the Society's Menagerie in the months of November and December, 1918.

Mr. C. Davies Sherborn, F.Z.S., exhibited and made remarks on a letter written in 1693, by Malpighi to Dr. Mathew Faber.

Sir Douglas Mawson read a communication on Australasian, Antarctic, and Subantarctic Life, and exhibited a large series of lantern-slides illustrating the scenery and mammals and birds of the South Polar Zone. He commented on the urgent need of international measures to preserve the fauna of these regions. The Chairman, expressing the sense of the Meeting, assured Sir Douglas Mawson of the active sympathy and support of the Zoological Society.

A communication by Mr. R. I. Pocock was deferred to the next Meeting, with the consent of the Author.

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* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W., on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

The next Meeting of the Society for Scientific Business will be held on Tuesday, February 18th, 1919, at 5.30 P.M., when the following communications will be made:—

R. I. Pocock, F.R.S., F.Z.S.

On the External Characters of the Existing Chevrotains. (Illustrated by lantern-slides.)

K. M. Smith.

A Comparative Study of certain Sense-Organs in the Antennæ and Palpi of Diptera. (Illustrated by lantern-slides.)

The following Papers have been received:—

G. A. Boulenger, F.R.S., F.Z.S.

On a Collection of Fishes from Lake Tanganyika, with Descriptions of Three new Species.

Miss Joan B. Procter, F.Z.S.

On the Skull and Affinities of *Rana subsigillata*, A. Dum.

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. This will render it necessary for the present that papers should be condensed, and be limited so far as possible to the description of new results.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

Zoological Society of London,
Regent's Park, London, N.W. 8.
February 11*th*, 1919.

No. 188.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

February 18th, 1919.

A. Smith Woodward, Esq., LL.D., F.R.S., Vice-President, in the Chair.

The Secretary read a Report on the Additions to the Society's Menagerie in the month of January 1919.

Mr. R. I. Pocock, F.R.S., F.Z.S., read a paper upon the external characters of existing Chevrotains (Tragulina), and showed that the Indian species, commonly cited as *Tragulus meminna*, differs in so many important characters from the Malaysian species that it is necessary to sever it from them as a distinct genus, for which the name *Moschiola*, used by Thomas in a subgeneric sense, is available. In the absence of the interramal scent-gland, in the structure of the penis, and in the retention of spots on the pelage, *Moschiola* is a more primitive type than *Tragulus*, and resembles the still more primitive West African genus *Hyemoschus*.

Prof. H. Maxwell Lefroy, M.A., F.E.S., communicated a paper by Mr. K. M. Smith, on "A Comparative Study of certain

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Sense-Organs in the Antennæ and Palpi of Diptera" (illustrated by lantern-slides).

The next Meeting of the Society for Scientific Business will be held on Tuesday, March 4th, 1919, at 5.30 P.M., when the following communications will be made:—

Dr. J. A. MURRAY, F.Z.S., Acting Honorary Pathologist.

Report on the Deaths in the Gardens during the Year 1918.

G. A. BOULENGER, F.R.S., F.Z.S.

On a Collection of Fishes from Lake Tanganyika, with Descriptions of Three new Species.

Miss JOAN B. PROCTER, F.Z.S.

On the Skull and Affinities of *Rana subsigillata*, A. Dum.

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. This will render it necessary for the present that papers should be condensed, and be limited so far as possible to the description of new results.

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P. CHALMERS MITCHELL,
Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W. 8.
February 20th, 1919.

No. 189.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

March 4th, 1919.

Dr. A. Smith Woodward, F.R.S., Vice-President, in the Chair.

Dr. J. A. Murray, F.Z.S., read a report on the deaths in the Gardens during the year 1918, illustrating his remarks with lantern-slides.

Mr. G. A. Boulenger, F.R.S., F.Z.S., described a collection of Fishes from Lake Tanganyika, and drew attention to three new species.

Miss Joan B. Procter, F.Z.S., gave a short account of her paper "On the Skull and Affinities of *Rana subsigillata*," drawing attention to several cranial characters either peculiar to this frog or held in common with *R. adspersa*, its nearest ally.

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The next Meeting of the Society for Scientific Business will be held on Tuesday, March 18th, 1919, at 5.30 P.M., when the following communications will be made:—

H. R. A. Mallock, F.R.S., F.Z.S.

"Some Points in Insect Mechanics." (Illustrated with lantern-slides.)

F. Martin Duncan, F.R.M.S., F.R.P.S.

Exhibition of Photographs and Lantern-slides of Marine Zoology.

H. F. Blaauw, C.M.Z.S.

"On the Breeding of *Oryx gazella* at Gooilust."

The following Paper has been received:—

Lancelot T. Hogben, B.A., B.Sc.

"The Progressive Reduction of the Jugal in the Mammalia." (Communicated by Mr. H. W. Unthank, B.A., B.Sc., F.Z.S.)

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. This will render it necessary for the present that papers should be condensed, and be limited as far as possible to the description of new results.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

Zoological Society of London,
Regent's Park, London, N.W. 8.
March 11*th*, 1919.

No. 190.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

March 18th, 1919.

ALFRED EZRA, Esq., in the Chair.

The SECRETARY read a Report on the Additions to the Society's Menagerie in the month of February 1919.

Mr. H. R. A. MALLOCK, F.R.S., F.Z.S., gave an account of his investigations on "Some Points in Insect Mechanics," illustrating his remarks with lantern-slides and diagrams.

Mr. R. I. POCOCK, F.R.S., F.Z.S., communicated a paper by Mr. F. E. BLAAUW, C.M.Z.S., "On the Breeding of *Oryx gazella* at Gooilust."

Mr. F. MARTIN DUNCAN, F.R.M.S., exhibited a series of photographs and lantern-slides of Marine Zoology, and drew attention to the economic importance of marine biological investigation.

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The next Meeting of the Society for Scientific Business will be held on Tuesday, April 8th, 1919, at **5.30** P.M., when the following communications will be made :—

Dr. F. E. Beddard, F.R.S., F.Z.S.

Exhibition of, with remarks on, three fœtal Sperm-Whales.

Lancelot T. Hogben, B.A., B.Sc.

The Progressive Reduction of the Jugal in the Mammalia. (Communicated by Mr. H. W. Unthank, B.A., B.Sc., F.Z.S.)

G. A. Boulenger, F.R.S., F.Z.S.

Description of Two new Lizards and a new Frog from the Andes of Colombia.

The following have been arranged :—

April 29th, 1919. Dr. W. T. Calman, D.Sc., F.Z.S.

Exhibition of Marine Boring Animals.

May 13th, 1919. Lt.-Col. S. Monckton Copeman, F.R.S., F.Z.S.

Experiments on Sex Determination (illustrated by lantern-slides).

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. This will render it necessary for the present that papers should be condensed, and be limited as far as possible to the description of new results.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

Zoological Society of London,
Regent's Park, London, N.W. 8.
March 25th, 1919.

No. 191.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

April 8th, 1919.

Dr. S. F. Harmer, F.R.S., F.Z.S., Vice-President, in the Chair.

Dr. F. E. Beddard, F.R.S., F.Z.S., exhibited and made remarks on three fœtal Sperm-Whales, drawing attention to the smallest fœtus exhibited, which measured 4½ inches in length.

Mr. H. W. Unthank, B.A., B.Sc., F.Z.S., gave a résumé of Mr. Lancelot T. Hogben's Paper on "The Progressive Reduction of the Jugal in the Mammalia."

In the absence of Mr. G. A. Boulenger, F.R.S., F.Z.S., his communication on "Two new Lizards and a new Frog from the Andes of Colombia" was taken as read.

Mr. R. I. Pocock, F.R.S., F.Z.S., Curator of Mammals, gave an exhibition, illustrated by lantern-slides, to show some of the structural characters by which the genera of Felidæ may be distinguished from each other, special attention being drawn to the formation of the feet in the Cheetah (*Acinonyx*), to the modifications of the hyoidean apparatus in the Lions, Tigers, Leopards, and Jaguars (*Panthera*), and to the position of the partition in the auditory bulla in other genera.

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The next Meeting of the Society for Scientific Business will be held on Tuesday, April 29th, 1919, at **5.30** P.M., when the following communications will be made:—

Dr. W. T. CALMAN, D.Sc., F.Z.S.

Exhibition of Marine Boring Animals.

NOEL TAYLER, B.Sc.

A unique Case of Asymmetrical Duplicity in the Chick.

The following communication will be taken on

May 13th, 1919. Lt.-Col. S. MONCKTON COPEMAN, F.R.S., F.Z.S.

Experiments on Sex Determination (illustrated by lantern-slides).

The following Papers have been received:—

GEO. JENNISON, Esq.

"A Chimpanzee in the Open Air in England."

CLAUDE MORLEY, Esq., F.Z.S.

Equatorial and Other Species and Genera of African Ichneumonidæ.

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. This will render it necessary for the present that papers should be condensed, and be limited so far as possible to the description of new results.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W. 8.
April 15th, 1919.

No. 192.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

April 29th, 1919.

Prof. ERNEST W. MACBRIDE, D.Sc., LL.D., F.R.S., Vice-President, in the Chair.

The SECRETARY read a report on the Additions to the Society's Menagerie in the month of May, 1919.

Mr. T. GERRARD, F.Z.S., exhibited and drew attention to some special points of interest in a series of heads of Waterbuck (*Kobus*), collected by Dr. Digby.

Dr. W. T. CALMAN, D.Sc., F.Z.S., exhibited and gave a detailed account of various Marine Boring Animals, drawing attention to the economic importance of the scientific investigation of such forms of Marine Animals in relation to the serious damage caused by them to the timbers of wooden ships and to piers, and to the masonry of breakwaters and similar constructions.

The SECRETARY read a communication, illustrated by lantern-slides, from Mr. GEO. JENNISON, on "A Chimpanzee in the Open Air in England," drawing attention to the fact that the animal had lived in a healthy and vigorous condition for a period of some eight years in the private grounds of its owner, Dr. John K. Butter, of Cannock, Staffordshire.

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The next Meeting of the Society for Scientific Business will be held on Tuesday, May 13th, 1919, at 5.30 P.M., when the following communications will be made:—

Lt.-Col. S. MONCKTON COPEMAN, F.R.S., F.Z.S.

Experiments on Sex Determination (illustrated by lantern-slides).

NOEL TAYLER, B.Sc.

A unique Case of Asymmetrical Duplicity in the Chick.

The following Papers have been received:—

CLAUDE MORLEY, F.Z.S.

Equatorial and other Species and Genera of African Ichneumonidæ.

ERNEST E. UNWIN.

On the Structure of the Respiratory Organs of the Terrestrial Isopoda.

J. T. CUNNINGHAM, M.A.

Result of a Mendelian Experiment on Fowls, including the Production of a Pile Breed.

C. W. ANDREWS, D.Sc., F.R.S., F.Z.S.

A Description of New Species of Zeuglodons and Leathery Turtle from the Eocene of Southern Nigeria.

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. This will render it necessary for the present that papers should be condensed, and be limited so far as possible to the description of new results.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

Zoological Society of London,
Regent's Park, London, N.W. 8.
May 6th, 1919.

No. 193.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

May 13th, 1919.

Prof. Ernest W. MacBride, D.Sc., LL.D., F.R.S., Vice-President, in the Chair.

The Secretary exhibited two photographs of a living Okapi, and stated that the animal had been in the possession of its present owners for a period of over three years. The photographs showed that it was a young animal, and that probably, as in the case of the Giraffe, the Okapi does not reach its adult stage until five or six years of age.

Mr. E. G. Boulenger, F.Z.S., exhibited a series of living specimens of the British Rats and their varieties, and stated that during the past four years there was evidence that the so-called Old English Black Rat had increased in numbers.

Prof. J. P. Hill, F.R.S., F.Z.S., gave a *résumé* of Mr. Noel Tayler's communication on "A unique Case of Asymmetrical Duplicity in the Chick," and illustrated his remarks by a series of lantern-slides.

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Lt.-Col. S. Monckton Copeman, F.R.S., F.Z.S., read a paper on "Experiments on Sex Determination," and illustrated his remarks by a series of lantern-slides of carefully prepared charts.

The next Meeting of the Society for Scientific Business will be held on Tuesday, May 27th, 1919, at **5.30** p.m., when the following communications will be made:—

J. T. Cunningham, M.A., F.Z.S.

On Result of a Mendelian Experiment on Fowls, including the Production of a Pile Breed.

Miss Kathleen F. Lander, B.Sc., F.Z.S.

Some Points in the Anatomy of the Takin (*Budorcas taxicolor whitei*).

Edward Phelps Allis, F.Z.S.

On certain Features of the Otic Region of the Chondrocranium of *Lepidosteus*, and Comparison with other Fishes and higher Vertebrates.

The following Papers have been received:—

Claude Morley, F.Z.S.

Equatorial and other Species and Genera of African Ichneumonidæ.

C. W. Andrews, D.Sc., F.R.S., F.Z.S.

A Description of New Species of Zeuglodons and Leathery Turtle from the Eocene of Southern Nigeria.

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. This will render it necessary for the present that papers should be condensed, and be limited so far as possible to the description of new results.

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P. CHALMERS MITCHELL,
Secretary.

Zoological Society of London,
Regent's Park, London, N.W. 8.
May 20*th*, 1919.

Lt.-Col. S. Monckton Copeman, F.R.S., F.Z.S., read a paper on "Experiments on Sex Determination," and illustrated his remarks by a series of lantern-slides of carefully prepared charts.

The next Meeting of the Society for Scientific Business will be held on Tuesday, May 27th, 1919, at **5.30** p.m., when the following communications will be made:—

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On Result of a Mendelian Experiment on Fowls, including the Production of a Pile Breed.

Miss Kathleen F. Lander, B.Sc., F.Z.S.

Some Points in the Anatomy of the Takin (*Budorcas taxicolor whitei*).

Edward Phelps Allis, F.Z.S.

On certain Features of the Otic Region of the Chondrocranium of *Lepidosteus*, and Comparison with other Fishes and higher Vertebrates.

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Secretary.

Zoological Society of London,
Regent's Park, London, N.W. 8.
May 20*th*, 1919.

No. 194.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

May 27th, 1919.

A. Smith Woodward, Esq., LL.D., F.R.S., Vice-President,
in the Chair.

The Secretary read a Report on the Additions to the Society's Menagerie in the month of April, 1919.

Mr. J. T. Cunningham, M.A., F.Z.S., communicated his paper on the "Result of a Mendelian Experiment on Fowls, including the Production of a Pile Breed."

Miss Kathleen F. Lander, B.Sc., F.Z.S., described some Points in the Anatomy of the Takin (*Budorcas taxicolor whitei*), and illustrated her remarks by a series of lantern-slides.

In the absence of the Author, Mr. E. Phelps Allis, F.Z.S., his communication "On certain Features of the Otic Region of the Chondrocranium of *Lepidosteus*, and Comparison with other Fishes and higher Vertebrata," was taken as read.

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The SECRETARY exhibited, and made some additional remarks upon the photographs of a young living Okapi that were shown at the previous Scientific Meeting.

The next Meeting of the Society for Scientific Business will be held on Tuesday, June 17th, 1919, at **5.30** P.M., when the following communications will be made:—

EDWARD HERON-ALLEN, F.R.S., F.Z.S., and ARTHUR EARLAND, F.R.M.S.

Exhibition of Lantern-slides illustrating the cultivation of *Verneuilina polystropha* Reuss., in hypertonic sea-water and gem-sand.

CLAUDE MORLEY, F.Z.S.

Equatorial and other Species and Genera of African Ichneumonidæ.

C. W. ANDREWS, D.Sc., F.R.S., F.Z.S.

A Description of New Species of Zeuglodons and Leathery Turtle from the Eocene of Southern Nigeria.

G. A. BOULENGER, F.R.S., F.Z.S.

(1) A List of the Snakes of West Africa from Mauritania to the French Congo.

(2) A List of the Snakes of North Africa.

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. This will render it necessary for the present that papers should be condensed and be limited so far as possible to the description of new results.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W. 8.
June 3rd, 1919.

No. 195.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

June 17th, 1919.

Prof. E. W. MACBRIDE, F.R.S., F.Z.S., Vice-President, in the Chair.

The SECRETARY read a Report on the Additions to the Society's Menagerie during the month of May, 1919.

Mr. J. T. CARTER, F.Z.S., gave a *résumé* of his paper on the "Occurrence of Denticles on the Snout of *Xiphias*."

Miss L. E. CHEESMAN, F.E.S., exhibited some living specimens of Light-giving Beetles from Cuba.

Dr. C. W. ANDREWS, F.R.S., F.Z.S., communicated his paper on "New Species of Zeuglodons and a Leathery Turtle from the Eocene of Southern Nigeria."

Mr. EDWARD HERON-ALLEN, F.R.S., F.Z.S., described the experiments he had been carrying out in collaboration with Mr. ARTHUR EARLAND, F.R.M.S., on the cultivation of *Verneuilina polystropha* Reuss in hypertonic sea-water and gem sand, and illustrated his remarks with a series of lantern-slides.

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In the absence of the Authors, the following communications were taken as read:—Mr. CLAUDE MORLEY, F.Z.S., "Equatorial and other Species and Genera of African Ichneumonidæ." Prof. G. A. BOULENGER, F.R.S., F.Z.S., (1) "A List of the Snakes of West Africa from Mauritania to the French Congo," and (2) "A List of the Snakes of North Africa." Rev. THOMAS R. R. STEBBING, F.R.S., F.Z.S., "Crustacea from the Falkland Islands collected by Mr. Rupert Vallentin: Part III."

This Meeting closes the Session 1918–1919. The next Meeting of the Society for Scientific Business will be held on Tuesday, October 21st, 1919, at 5.30 P.M.

The following communications have been received:—

B. L. BHATIA, M.Sc.

Notes on Indian Ciliate Protozoa.

E. DUKINFIELD JONES, F.Z.S., F.E.S.

Descriptions of New Moths from South-East Brazil.

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. This will render it necessary for the present that papers should be condensed and be limited so far as possible to the description of new results.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W. 8.
June 23rd, 1919.

No. 196.

ABSTRACT OF THE PROCEEDINGS
OF THE
ZOOLOGICAL SOCIETY OF LONDON.*

October 21st, 1919.

Prof. E. W. MacBride, F.R.S., F.Z.S., Vice-President, in the Chair.

The Secretary read a Report on the Additions made to the Society's Menagerie during the months of June, July, August, and September.

Mr. Oldfield Thomas, F.R.S., exhibited three interesting Mammals obtained by Dr. Aders, F.Z.S., in Zanzibar: namely, an example of *Cephalophus adersi*, a recently described new species; an example of *Colobus kirki*, which until lately was supposed to be almost extinct, and a specimen of a rare Insectivore belonging to the genus *Petrodromus*.

Mr. E. G. Boulenger, F.Z.S., read a "Report on the Research Experiments on Methods of Rat Destruction carried out at the Society's Gardens," and exhibited some of the traps that had proved most successful.

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* This Abstract is published by the Society at its offices, Zoological Gardens, Regent's Park, N.W., on the Tuesday following the date of Meeting to which it refers. It will be issued, along with the 'Proceedings,' free of extra charge, to all Fellows who subscribe to the Publications; but it may be obtained on the day of publication at the price of *Sixpence*, or, if desired, sent post-free for the sum of *Six Shillings* per annum, payable in advance.

Dr. A. SMITH WOODWARD opened a "Discussion on the Zoological Position and Affinities of *Tarsius*," and the discussion was continued by Prof. F. WOOD JONES, D.Sc., F.Z.S., Prof. J. P. HILL, F.R.S., F.Z.S., and Dr. G. ELLIOTT SMITH, M.A., F.R.S., F.Z.S. Contributions by Mr. R. I. Pocock, the Secretary, and the Chairman had to be taken as read.

The next Meeting of the Society for Scientific Business will be held on Tuesday, November 4th, 1919, at **5.30** P.M., when the following communications will be made:—

E. HERON ALLEN, F.R.S., F.Z.S.

Exhibition of Skiagraphs of *Vermiculina* from examples grown in a hypertonic tank.

GUY MARSHALL, D.Sc., F.Z.S.

On the Species of *Balaninus* occurring in Borneo (Coleoptera, Curculionidæ).

Miss JOAN B. PROCTOR, F.Z.S.

On the Variation in the Number of Dorsal Scale-rows in our British Snakes.

G. A. BOULENGER, F.R.S., F.Z.S.

On some new Fishes from near the West Coast of Lake Tanganyika.

The Hon. PAUL METHUEN, F.Z.S.

Description of a new Snake from the Transvaal, together with a new Diagnosis and Key of the Genus *Xenocalmus*, and of some Batrachia from Madagascar.

The following Papers have been received:—

M. TURNER, B.Sc.

On the Nematode Parasites of a Chapman's Zebra.

Rev. A. H. Cooke, F.Z.S.

The Radula of the Mitridæ.

Major J. Stevenson Hamilton, C.M.Z.S.

Field-notes on some Mammals in the Bahr El Gebel, Southern Sudan.

Lt.-Col. S. Monckton Copeman, F.R.S., F.Z.S.

Experiments on Sex Determination.

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. This will render it necessary for the present that papers should be condensed and be limited so far as possible to the description of new results.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

Zoological Society of London,
Regent's Park, London, N.W. 8.
October 27th, 1919.

No. 197.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

November 4th, 1919.

A. SMITH WOODWARD, Esq., LL.D., F.R.S., Vice-President,
in the Chair.

Mr. F. MARTIN DUNCAN, F.R.M.S., F.Z.S., exhibited a series of photographs showing the actinic quality of the light from a living *Pyrophorus* Beetle, and, in describing the method employed to obtain the records, stated that photo-spectroscopically the greatest intensity of light action appeared to be in the yellow-green region.

Mr. E. HERON-ALLEN, F.R.S., F.Z.S., exhibited a series of Skiagraphs of the Foraminiferan genus *Verneuilina* from examples grown in a hypertonic tank, and described some further results that he and Mr. A. Earland, F.R.M.S., had obtained in the course of their investigations.

Miss JOAN B. PROCTOR, F.Z.S., communicated her paper on "The Variation in the Number of Dorsal Scale-rows in our British Snakes."

Dr. G. A. BOULENGER, F.R.S., F.Z.S., gave a *résumé* of his paper on "Some new Fishes from near the West Coast of Lake Tanganyika."

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In the absence of the Authors, the following communications were taken as read:—Mr. Guy Marshall, D.Sc., F.Z.S., "On the Species of the *Balaninus* occurring in Borneo (Coleoptera, *Curculionidæ*)"; The Hon. Paul Methuen, F.Z.S., "Description of a new Snake from the Transvaal, together with a new Diagnosis and Key of the Genus *Xenocalamus*, and of some Batrachia from Madagascar.

Prof. J. P. Hill, F.R.S., F.Z.S., exhibited and described a series of lantern-slides illustrating the placentation of *Tarsius*.

Mr. R. I. Pocock, F.R.S., F.Z.S., exhibited a series of lantern-slides illustrating some of the external characters of *Tarsius*.

The next Meeting of the Society for Scientific Business will be held on Tuesday, November 18th, 1919, at **5.30** P.M., when the following communications will be made:—

Sir Edmund Giles Loder, Bt., F.Z.S.

Exhibition of the skull of a Beaver.

Major J. Stevenson Hamilton, C.M.Z.S.

Field-Notes on some Mammals in the Bahr el Gebel, Southern Sudan.

J. F. Gemmill, M.A., M.D., D.Sc., F.Z.S.

(1) The Development of the Mesenteries in *Urticina crassicornis* (Actinozoa).

(2) The Leptomedusan *Melicertidium octocostatum*.

M. Turner, B.Sc.

On the Nematode Parasites of a Chapman's Zebra.

Rev. A. H. Cooke, F.Z.S.

The Radula of the Mitridæ.

Lt.-Col. S. Monckton Copeman, F.R.S., F.Z.S.

Experiments on Sex Determination.

Chas. F. Sonntag, M.D., Ch.B., F.Z.S.

The Variations in the Digastric Muscle of the Rhesus Macaque and the Common Macaque.

E. S. Russell, M.A., B.Sc., F.Z.S.

Note on the Righting Reaction in *Asterina gibbosa* Penn.

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. This will render it necessary for the present that papers should be condensed and be limited so far as possible to the description of new results.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

Zoological Society of London,
Regent's Park, London, N.W. 8.
November 10*th*, 1919.

No. 198.

ABSTRACT OF THE PROCEEDINGS

OF THE

ZOOLOGICAL SOCIETY OF LONDON.*

November 18th, 1919.

Prof. E. W. MACBRIDE, F.R.S., F.Z.S., Vice-President,
in the Chair.

The SECRETARY read a Report on the Additions made to the Society's Menagerie during the month of October, 1919.

The SECRETARY exhibited and made remarks on a photograph of a White Tiger.

Sir EDMUND GILES LODER, Bt., F.Z.S., exhibited and made remarks on a series of skulls of the Beaver, exhibiting a separate ossicle between the parietals.

Major J. STEVENSON HAMILTON, C.M.Z.S., gave a *résumé* of his paper "Field-Notes on some Mammals in the Bahr el Gebel, Southern Sudan," and illustrated his remarks by means of a fine series of skins.

In the absence of the Author, Prof. J. F. GEMMILL, M.A., M.D., D.Sc., his papers (1) "The Development of the Mesenteries in *Urticina crassicornis* (Actinozoa)," and (2) "The Leptomedusan *Melicertidium octocostatum*," were taken as read.

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The Rev. A. H. COOKE, Sc.D., F.Z.S., gave a *résumé* of his paper on "The Radula of the Mitridæ."

Dr. CHAS. F. SONNTAG, F.Z.S., communicated his paper on "The Variations in the Digastric Muscle of the Rhesus Macaque and the Common Macaque."

Mr. E. S. RUSSELL, M.A., B.Sc., F.Z.S., communicated his paper on "The Righting Reaction in *Asterina gibbosa* Penn," illustrating his remarks with a model showing the "deadlock" position in the righting reaction, caused by the middle ray lagging behind.

In the absence of the Authors, the following papers were taken as read:—Lt.-Col. S. MONCKTON COPEMAN, F.R.S., F.Z.S., "Experiments on Sex Determination"; M. TURNER, B.Sc., "On the Nematode Parasites of a Chapman's Zebra."

The next Meeting of the Society for Scientific Business will be held on Tuesday, February 10th, 1920.

A Notice stating the Agenda for that Meeting will be circulated early in February.

The following Papers have been received:—

R. E. TURNER and J. WATERSTON.

A Revision of the Ichneumonid Genera *Labium* and *Pœcilocryptus*.

F. D. WELCH, M.R.C.S.

Remarks on Forster's Milvago or Carrion-Hawk.

E. HERON-ALLEN and A. EARLAND.

An Experimental Study of the Foraminiferal Species *Verneuilina polystropha* (Reuss), and some others, being a Contribution to a Discussion "On the Origin, Evolution, and Transmission of Biological Characters."

The Publication Committee desire to call the attention of those who propose to offer Papers to the Society, to the great increase in the cost of paper and printing. This will render it necessary for the present that papers should be condensed, and be limited so far as possible to the description of new results.

Communications intended for the Scientific Meetings should be addressed to

P. CHALMERS MITCHELL,
Secretary.

ZOOLOGICAL SOCIETY OF LONDON,
REGENT'S PARK, LONDON, N.W. 8.
November 29th, 1919.

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